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ABSTRACT

The following papers are included: "Technological Literacy: What? Why? For Whom?" (Kranzberg); "Techniliterate vs. Technilliterate (There's an L of a Difference)" (Stone); "International Perspectives on Technological Literacy" (Dyrenfurth); "Technology and the Liberal Arts: Are We Producing Technopeasants?" (Brockway); "Study on the Justification of Technology Education as General Education" (Chang); "A Case for Technological Literacy" (Martin); "Technology: The Newest Liberal Arts" (Kowal); "The Underside of Technological Literacy" (Pilotta); "Impacts of Technology" (Balistreri); "Christian Relational Theology as a Framework for Assessing for Moral and Social Implications of Technology" (Arnett, Ramer); "Social Consequences of Technological Innovation" (Pucciano); "Sociotechnical Literacy: An Alternative to the Technological Perspective" (Pratzner); "A Global Model of Technological Literacy" (Hameed); "Defining, Determining, and Contributing to Technological Literacy: Getting There from Here Using the Technology of a Research Paradigm" (White); "What Price Progress? The Social Impact of Technology on Society" (Meyers); "An International Study of Curricular Organizers for the Study of Technology" (Barnes); "An Instructional Model for Electronics Technology in the Republic of China" (Shih); "'Jackson's Mill' and 'Industry and Technology Education' Project Reports as a Guide for Organizing Content for Technology Education" (Wright); "The Future of Work in America: Workers, the Workplace, and Technological Literacy" (Charner); "New Technology, New Lifestyles, and the Implications of Preservice and Inservice Vocational Teacher Education" (Worms, Worms); "Technology and Education: The Appropriate Threads for a Computer Tapestry" (Thomas); "Computer Literacy: An Essential Element of Technological Literacy" (Welty); "Computer Anxiety Levels Related to Computer Use and Teacher Inservice Educational Needs" (Malpiedi); "Energy Literacy: The Changing of Cocksure Ignorance to Thoughtful Uncertainty" (Singletary); "Florida's Assessment of Vocational Teachers' Training Needs: The First Step in a Five-Year Statewide Inservice Plan" (Patterson); "The Impact of Computer Technology on Graphic Communication" (Boyer, Bertoline); "Dichotomies, Relationships and the Development of Technological Literacy" (DeVore); "Technology's Impact on Education: Don't Leave It to Chance" (Harris); "Implications: Technological Literacy and Vocational Education Service Areas" (Ressler); "Machine Vision Literacy" (Andrews); "Technology Education in New York State" (Hacker); "Technological Literacy: Roles for Practical Arts and Vocational Education" (Maley); and "Technological Literacy: The Role of Vocational Education" (Moss). (MN)

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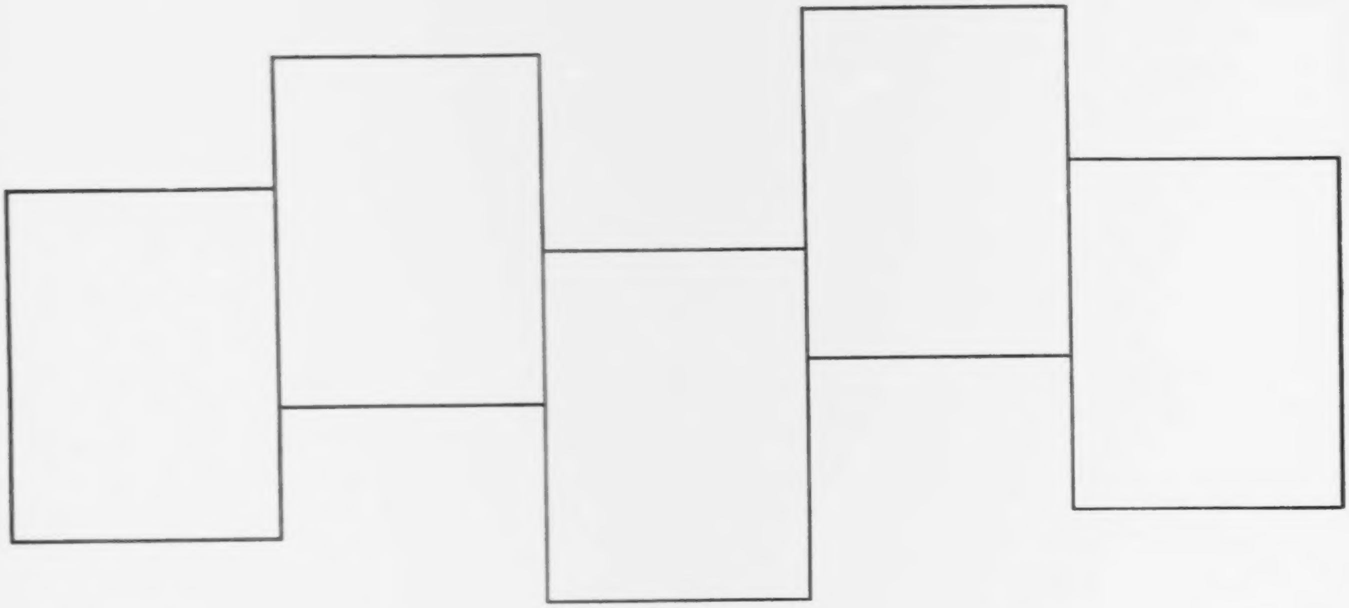

Proceedings from an International Symposium
on Technological Literacy
Columbus, Ohio
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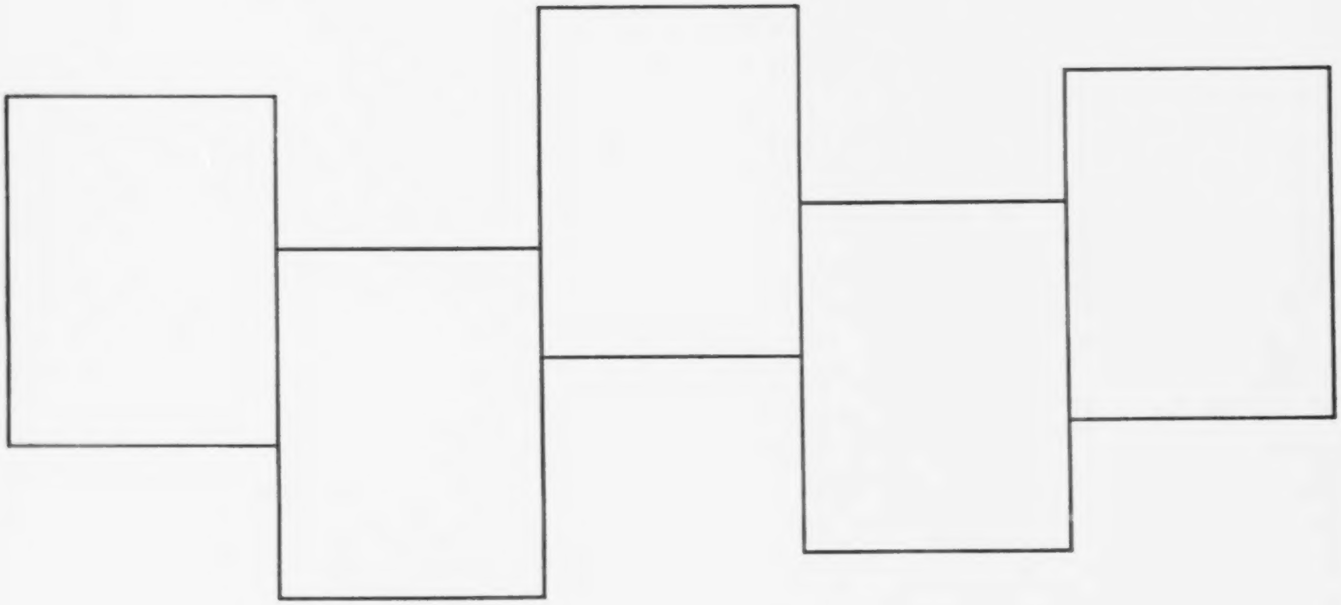

Edited by:
E. Keith Blankenbaker
Aaron J. Miller
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Preface

Work, leisure, education and lifestyles have changed radically since the turn of the century. Central to these changes have been the development of various new systems of technology and the consequences of their impact on our daily lives. Basic literacy skills have long been recognized as essential for all citizens to understand and live fulfilling lives in this culture. However, with the current and growing interrelationship of society and technology it now becomes essential that our citizenry become technologically literate. We must understand the basic principles and relationships of technology to the way we learn, live and work.

The International Symposium on Technological Literacy: The Roles of the Practical Arts and Vocational Education provided a national forum for examining some of the most critical issues related to the teaching of content necessary for technological literacy in our nation's schools. Further, it provided for the examination of these issues and their implications for appropriate curriculum development and program planning for students who chose either a vocational education curriculum or a college preparatory program at the high school level.

On May 13-16, 1987, The Ohio State University sponsored a symposium where papers on these significant issues were presented and discussed by a broad spectrum of both national and international experts in fields related to symposium topics. The proceedings contained in this document provided the essence of these major presentations and discussions.

E. Keith Blankenbaker
Aaron J. Miller

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E. Keith Blankenbaker
Aaron J. Miller

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Technological Literacy: What? Why? For Whom?

Dr. Melvin Kranzberg
Callaway Professor of the History of Technology
Georgia Institute of Technology
Atlanta, Georgia

The title of my talk--"Technological Literacy: What? Why? For Whom?"--consists of a series of questions. That befits a historian, because history is a series of questions we ask of the past in order to learn how our present world came into being, and also to see if the past can provide guidance for the future. The questions in my title are designed to find out if the past can shed some light on the roles of the practical arts and vocational education in producing the world of the future.

But every question leads to others. Thus when we ask, "What is technological literacy?", two additional questions immediately come to mind: "What is technology?" and "What is literacy?". Putting the answers together should tell us what is meant by "technological literacy."

But that is not so easy as it seems. For there are many different definitions of technology, and there is also some question about what constitutes literacy.

In the popular mind, technology is synonymous with tools, machines, devices, and processes; and one widely accepted description of technology is that it deals with how things are done or made and what things are done or made. But that broad definition encompasses many items that can scarcely be considered technological. Thus Congress "makes" laws--but that kind of making has little to do with technology. Hence a definition of technology might perhaps include the ends to which the making and doing of things is directed.

Some definitions of technology do stress a purposive element, describing it as "man's rational and ordered attempt to control nature." Here the definition is too tight, for while it would include much of technology, many technical activities and products would not fit within it. The making of toys, for example, does not constitute an attempt to control nature, but rather to teach or amuse children. Similarly, weapons are developed to control our fellow man, but not to control nature--and, indeed, certain technological actions despoil nature. Besides, much of our technology is devoted to elements of our physical environment that are not part of nature. For example, we devise various means to control the flow of traffic in congested cities; that is because man, with the aid of his technology, has created a man-made environment, not just a natural environment.

Technology, then, must also be viewed as a process as well as a group of artifacts. It deals with human work, with man's attempts to satisfy his wants by human action on physical objectives. Notice, I use the term "wants" instead of "needs," for human wants go far beyond the basic needs of food, clothing, and shelter. Technology ministers to those, of course, but it also helps man fulfill many other wants.

However, mention of the work aspect adds still another dimension to our definition of technology, for it implies the organization of tools and labor. These in turn involve production and distribution systems, which are also essential elements of technological activity.

To many people technology is simply "applied science." Science is defined as man's attempt to understand the physical world, while technology's role is to apply that knowledge to control the physical world. Science, then, is "know-why," and technology is "know-how."

While there can be no doubt that technology is indeed a form of knowledge--a special kind of knowledge of how to make and do certain kinds of things--the definition of technology as "applied science" ignores the historical evidence. For the fact is that throughout most of history, men made machines and products without understanding why they worked or comprehending their physical or chemical makeup. Besides, during the past century science and technology have been coming closer together, and, indeed, where does science end and technology begin in such fields as nuclear power, bio-engineering, and the like? Nowadays the sciences that rely so much upon technological instrumentation and devices that modern physics, chemistry, and biology, to say nothing of modern medicine, might well be called "applied technology."

Obviously, technology is not a simple thing. Instead, it involves distinctive modes of thought and action to serve diverse human needs, not only in making physical objects, but also in designing structures and environments to achieve varied goals. It utilizes varying rules, procedures, and forms of organization in order to accomplish a multitude of purposes.

All the difficulties that beset us in attempting to define technology actually lead to a very simple conclusion, namely, that technology is a very human activity--and, as such, it reflects all the complexities of the human condition.

Yet, to many humanists, technology is viewed as something divorced from mankind. Indeed, today's bleeding-heart humanists posit some sort of conflict between man and his technology, as if the two were somehow opposed to each other and locked in mortal combat.

I find that somewhat strange because the historical and, indeed, the prehistorical facts indicate quite the opposite: namely, that man and his technology are inextricably intertwined, that technology has served as one of man's chief tools as he sought to achieve his goals, both glorious and ignoble.

This symbiotic relationship between man and his technology goes back to the very beginning of our species. Anthropologists, seeking to differentiate between "almost-man" and the genus "man," find that man employed tools. Man as we know him could not have evolved or survived without tools; he is too weak and puny a creature to fight nature with only his hands and teeth. The lion is stronger, the horse is faster, the giraffe can reach higher; but tools served as extensions of man's hand and amplifiers of his muscle power, enabling him to adjust his hereditary organic equipment to an almost infinite number of operations in virtually any environment.

It is not surprising, therefore, that some anthropologists define the human species on the basis of tool-using and tool-making, or to be more exact, tool dependency. Modern physiology, psychology, evolutionary biology, and anthropology--all combine to demonstrate to use that *homo sapiens* (man the thinker) cannot be distinguished from *homo faber* (man the maker). Indeed, we now realize that man could not have become a thinker had he not at the same time been a maker. Thus we find that technology is perhaps one of the earliest and most basic of human cultural characteristics. As far back as 1836, Thomas Carlyle recognized this when he said in *Sartor Resartus*, "Man is a tool-using animal. Without tools he is nothing; with tools he is all."

From savagery to barbarism to civilization, man's material progress throughout the ages has been bound up with his technology. Indeed, we have become so accustomed to it that we take our technology for granted, failing to realize how unique and significant it is until a storm causes an electrical malfunction or some technical device goes on the blink. I'm reminded of an airplane, one of the technical marvels of our time: "No siree," she said, "not for me. I'm going to sit right here on earth and watch television, just the way the good Lord intended me to."

Despite the role of technology in the vast panorama of human history, we constantly come up against those who regard technology as something divorced from the essence of humanity. My humanist colleagues ask: What is human about a monkey wrench, a lathe, a computer? What repels them about technology is what they term the "inhumanity" of its objects, for example, the industrial robots which they fear will make man expendable, or the "antihumanity" of its by-products, such as the pollution which threatens our environment.

It is true that we ordinarily think of technology as something mechanical, yet the fact is that all technical processes and products are the result of the human creative imagination and human skills, mind and hands working together.

Technology is inseparable from men and communities. The technologist is concerned with the applications of science and other forms of knowledge to the needs and wants of man and society; he is up to his neck in human problems whether he likes it or not.

The significance of technology lies in its use by human beings--what it does. Take, for example, the telephone. If we regard the telephone only as a collection of wires through which current passes from transmitter to a receiver, the telephone would seem to have little interest, except for telephone technicians and repairmen and the successors to AT&T. But the real significance of the telephone lies in its use in transmitting messages. It is the communications function of the telephone that gives it importance--and the function of all technology is its use by human beings--and sometimes, alas, its misuse and abuse.

You see, machines are not something apart from mankind. Behind every machine I see a face, indeed, many faces: the workers, the scientist, the engineer, the businessman or business woman, and sometimes the General or Admiral.

But because technology is such a thoroughly human activity, it is constantly evolving. Human institutions, human activities, human capabilities, human wants and desires have changed over time--and this is largely due to technological advances. The technology necessary to wrest a living from nature in the Stone Ages is quite different from that required to keep a highly complex, urbanized society alive and functioning. Learning to chip flakes of flint in order to make spears and arrowheads--the vocational education of the Stone Age--will no longer suffice to obtain a food supply, keep warm and comfortable, and enjoy living in today's "Technological Age."

I shall return to this subject of today's sophisticated technology--and the education needed for it--later. But first we must define "literacy," in order to see what is meant by "technological literacy."

The dictionary does not give us much help. It defines "literacy" as "the state or condition of being literate," and "literate" is defined as "having a knowledge of letters; able to read and write."

Extending that definition to the field of technology, literacy would mean something like, "able to do technology." But, as we have just seen, the technological enterprise involves many varying activities.

The Pennsylvania State University Program on Science Through Science, Technology and Society has sponsored two national conferences on Technological Literacy during the past few years, and at these conferences a plethora of definitions emerged. That is not surprising, considering the many and varied activities of technology itself.

The difficulty of nailing down what is meant by "technological literacy" was compounded when the Sloan Foundation generated its "New Liberal Arts" program at the beginning of the 1980s. Most of the Sloan grants focused on the computer, with the result that technological literacy became identified with computer literacy. While the computer is one of the fundamental artifacts of our present age, it is far from being the sole technological component of our times. Computer literacy involves skill in learning how to use a sophisticated tool, but it certainly does not constitute full acquaintance with the many parameters of technical activities nor with the technological dimensions of society.

At the end, I was forced to attempt to distill my own--but still incomplete--definition. To me, technological literacy has two major and interrelated components. First, is the understanding of the character of technology itself--the type of problems which it addresses and the various modes of thought and action applied to resolving these problems. This requires understanding of some basic technical principles, and also some hands-on experience in order to recognize the practical problems encountered in technological design and practice.

The second major component of technological literacy involves comprehension of the non-technical factors entering into technical problems and their solutions, which includes the impacts--both benefits and risks--of varying designs and decisions. This requires some larger understanding of technology's interactions with society.

Now let us see how this bipartite technological literacy might apply to some specific cases. To many people, the technological devices which form so much a part of our daily lives are "black boxes" whose internal operations are mysteries, and whose results are frequently viewed with a mixture of awe and fear. Technological literacy would include knowledge of the operations going on within it. More than that, it would also require appreciation of the input and output factors of the black boxes, which in turn would involve some understanding of the implications of technology for the individual, society, and the environment--and an awareness of the ethical and moral questions which have recently been raised regarding our enlarged technological capabilities.

Of course, those actually engaged in making and using it must know what is inside the technological "black box," but even those not directly involved should acquire some comprehension of the basic concepts and practices of the technology if they wish to participate meaningfully in our technological world. Such comprehension should not impose insuperable difficulties, for one can*understand* technical devices, problems, and practices without being an expert in making, repairing, or operating them. For example, lots of us are reasonably aware of how a plane flies, for we have at least a rudimentary understanding of the principles of aerodynamics, not necessarily from studying physics but from having flown kites or model planes as kids. But even if we understand how a plane flies, that does not mean that we are qualified to fly one and certainly not to design one.

What I am saying is that the underlying concepts and operations of technical objects, including the baffling innards of microchip devices, can be understood by most American students. And even though we can utilize many technical devices without knowing exactly what goes on inside the "black box," we can do still better if we possess some technical know-how. For example, we can drive an automobile without knowing the principles of thermodynamics or the exact workings of an internal-combustion engine. Nevertheless, if we do have some knowledge of how the engine actually runs, how the braking system works, and the like, we can drive the car more efficiently and safely and see to its proper maintenance.

But if we can use our cars, watches, microwave ovens, television sets, and all the other technical apparatus of our daily lives without having full comprehension of their technical operations, why is technological literacy so desirable? Because technological literacy includes more than comprehension of the technical elements themselves; it also requires understanding of the ways in which technology interacts with society. After all, technology affects how and where we work, live, think, play, and pray--and it has an important bearing on the future. We call ours a Technological Age, and if we want to understand the times in which we live, we must acquire technological literacy.

The point is that every technological activity has non-technical ramifications, and not everyone agrees that these are beneficial to mankind. While we can point to many wonderful things that technology has brought to society, many sensitive individuals fear that this very human activity--technology--has grown so large and has presented mankind with such awful by-products that it threatens to engulf man. They point to the inhuman uses to which technology has been put. What about the devastation wrought by wars throughout the centuries, and the present possibility of destroying much of our planet through nuclear warfare? What about the deterioration of our environment by air and water pollution, the spoliation of the countryside, the rot of our cities? Technology, they claim, has destroyed the ecological balance between man and nature; not only that, but we are robbing future generations of their inheritance by plundering the earth of irreplaceable natural resources.

Now the interaction of technology with both the social and natural ecology is not always easy to trace. Yet that is necessary if we wish to understand the society in which we live--and, very importantly, seek to better its future.

Understanding the interactions of technology with society is advanced by knowing the principles and operations of the technology itself. And that puts a special burden on those involved with vocational and technical education at all levels.

Let me put the problem this way. Because ours is a technological society, there is need for technological knowledge and skills of many different kinds to serve the diverse needs of modern society. And because technology is constantly changing, technical education must also keep changing. And we can see these changes occurring at every level of technical training.

Forty years ago everybody knew that an engineer was a man who wore hip boots and a mackinaw and who built bridges, dams and roads, laid power lines, constructed electric generating plants and factories, and designed and made the machinery that went into them.

Engineers still do that, but they also do much more. They design and build delicate and complex instruments and machines that explore the depths of the earth and probe the farthest reaches of our solar system. The venture into the nucleus of the atom and extract power from it, they reach into the heart of an individual cell and change its genetic character so that it can produce materials and resources in infinite measure and replacement amounts. They create electric devices that transform communications and transportation, affect our collection and use of knowledge, and which alter our daily lives and work in countless ways.

Because these new tasks require heightened mathematical ability and deeper scientific understanding, engineering education has been thoroughly transformed in the decades since World War II. Instead of the hands-on, skill-oriented training which had characterized the earlier engineering curriculum, more courses in mathematics and the basic sciences were required. Engineering colleges even began requiring a healthy dosage of the humanities and social sciences, so as to enable their graduates to understand the context of the society in which they carried on their technological activity.

But just because engineers were engaged in these newfangled activities did not mean that our industrial society was no longer building dams, bridges, and roads; that we were no longer engaged in constructing power plants, factories, and machines to produce goods. Furthermore, we still must maintain our functioning technical operations.

Besides, even the new "high-technology" fields--computers, robotics, genetic engineering, and the like--require skilled technical personnel. Gene-splicers can develop new strains of disease-resistant and fast-growing plants and animals, but their researches would be ineffective unless there were also trained individuals to apply these to actual food production. Computer scientists and engineers can design highly-sophisticated machines, but unless there are skilled programmers, trained technicians, and reliable maintenance personnel, their work would go for naught. In addition to the family doctor our health services require laboratory technicians and operators of intricate diagnostic and life-maintenance devices in order to perform the miracles of modern medicine.

It is no wonder that in the past few decades there has sprung up a whole new body of technical professionals upon whom we rely for the effectiveness of the science and technology which are so essential to our lives. We give the title of "engineering technology," "vocational education," and "industrial education," to their curricula. They are necessary to maintain our society, not just its technical aspects, but also its sociocultural elements. Referring to the ties between the intellectual aspirations of a society and its materials and mechanical foundations, John Gardner, a former Secretary of Health, Education, and Welfare, said: "Our ideas won't hold water if we allow our plumbing to leak." Or, as industrial educator P. Cousins has written, "Technology can't get us to where we want to be unless we learn how to develop, train, manage, and support the 'human resources' who work with the technology."

In brief, the smooth functioning of our technological society and our ability to meet the sociotechnical problems of the future depend upon a high standard of education for technical personnel at all levels of our technological society. In contemporary America's "Technological Age," every member of society--whether or not he or she is employed directly in technical activities--must have some acquaintance with the basic "know-how" of our industrial technology. In brief, we should all be versed in the industrial and vocational arts, engineering and engineering technology, and all their relatives--and this educational process should extend from our earliest years throughout our lives.

To underline the importance of this kind of technical know-how, we need only to look at the plight of some of the developing countries today. Many of them, such as India, have highly-skilled engineers, but the lack of vocational and technical education throughout their society prevents them from being able to utilize their engineers most effectively. What they are missing is the wide range of skilled industrial personnel--the foremen, the skilled workers, the middle-level managerial personnel--who play so important a role in the American industrial scene. These are the sergeant-majors of the industrial process, and they are essential for productivity. Because these developing nations do not have this important middle group of technologists--just the kind that vocational, engineering technology, and industrial education programs prepare in this country--their productivity suffers. Unless they can overcome this great educational gap, they are doomed to remain behind. On the other hand, some Asiatic nations which have made great industrial progress recently--South Korea, Taiwan, and, of course, Japan--concentrated on developing such technical skills in their population.

An interesting characteristic of American society is that some technical know-how is the common property of all our citizens--largely because we have been trained in and exposed to technical devices throughout our lives.

This starts in the nursery. If you don't believe me, look at all the "creative" toys, the building blocks, the erector sets, the model kits, and the like which are part of growing up in America and have few counterparts elsewhere. In our secondary schools we have "shop" courses in making things, and we gain further technical familiarity through our informal and recreational activities, such as the computerized games in the shopping malls. Computerized toys and devices are commonplace nowadays, and, as the advertising unwittingly proclaims, "Toys 'R' Us," in the sense that technical gadgets are an integral part of our daily lives, both young and old.

What I am saying is that contemporary American society provides us with a familiarity with technology which provides a basis for obtaining the knowledge of technical principles and practices that is essential for technological literacy.

Compare this with the situation in those parts of the globe which have not yet fully entered into today's Technological Age. Several years ago I had occasion to speak at the University of Bandung in Indonesia. My hosts graciously gave me a tour of the area, and they took particular pride in showing me a new factory, owned by the Phillips Company of the Netherlands, where electronic components were being assembled. At the entrance to the factory grounds was a gigantic tree trunk, some 30 feet long and a yard in diameter, lying on its side. This tree trunk was almost completely studded with nails.

My guide asked me if I knew the purpose of the tree trunk with all the nails in it. Having been told at a cocktail party the evening before of the persistance of animistic beliefs on the nearby island of Bali, I replied that the nails were probably hammered in to keep the evil spirits away from the factory.

"That is a very perceptive observation, Dr. Kranzberg," my host replied, "but you are wrong. Those nails represent the entrance examination for employment in this factory."

"What do you mean?" I asked.

His response made my jaw drop. "Well," he said, "most of the common workers in this factory come from the nearby villages, which are still quite primitive--indeed, almost back in the Stone Age. They have never used a hammer and nail, so when they apply for a job here, we show them how to hammer a nail into this tree trunk. Then we give them a hammer and three nails; if they can drive these nails straight into the trunk within five minutes, we know that they possess sufficient hand-eye coordination and that they are teachable enough to learn how to put together electronic components. That means they have passed our entrance examination, so we hire them and put them into our training program at the factory."

Compare that with our technologically-oriented American society, where kids are pounding and putting things together in pre-kindergarten classes and where adults attend 'how-to" evening classes to learn how to refinish furniture, repair engines and household appliances, work with computers, and the like.

The fact is that the technical arts are pervasive throughout all levels of our society. But that does not necessarily mean that we understand the principles and operations of the technical devices and are cognizant of their interactions with our society, that is, that we possess technological literacy.

Yet we are attempting to remedy this grave omission. I find it both heartening and significant that industrial, technological, and vocational education have been keeping pace with the changing needs of our technological society and have been moving in the direction of technological literacy. Many years ago, industrial arts and vocational education taught the handicraft skills belonging to a pre-industrial society; in a sense they were a continuation of the old apprenticeship training. Some sixty years ago when I took "manual training," as we called it then, we were taught carpentering skills, and I made a breadboard and a birdhouse.

Such carpentering skills are still useful, but we need many others. Today, newer and more sophisticated technologies are being taught in practical arts curricula. More than that, vocational and technological educators have responded to the need for a general understanding of our industrial system by innovative programs which endeavor to impart that knowledge and also give their students some sense of pride and identity. Thus the original "skills" mission of vocational and technical education has undergone enlargement; it now also provides career exploration, occupational orientation, and prevocational experience.

But what good are industrial and vocational education, engineering technology, and engineering in a country which seems to be rapidly going downhill in terms of industrial production?

In the 19th century America moved from an agrarian society to an industrial one, but within recent decades we have moved from a manufacturing society to one that is service dominated. In the 1950s, the number of people engaged in service occupations for the first time exceeded those employed in producing goods. Furthermore, the introduction of automation and the growth of foreign imports has meant a further decline in industrial employment.

In the face of this structural change in employment and in light of growing foreign competition, some economists suggested a few years back that we write off our heavy industries, such as steel and automobiles, which had been the cornerstone of our nation's industrial growth. They claimed that America's industrial future lay in "high technology," meaning electronic and computerized devices of many kinds. Since America had led in developing computers, transistors, microchips, and integrated circuits, it was argued that we should abandon our older smokestack industries and concentrate on this new technology. This would usher in the "Information Age," wherein information would be the main product of our revitalized industrial system.

But wait a minute. We can't eat information, we can't drink it, we can't wear it, we can't drive it, and we can't live in it. Information is essential in producing better and cheaper food, shelter, clothing, and a whole host of other wants and needs, but to do that, it has to be used in connection with other productive technologies. I do not mean to belittle the importance of the Information Revolution, but to put it in its proper perspective: information is a means to help us in the production of more and better goods and services, in making life more comfortable, but certainly not an end in itself.

The new informational expertise, if embodied in computerized devices, including robotics, could help increase production, reduce prices and improve quality, thereby enabling us to compete on an international scale. But then we discovered that the Japanese were outstripping us even in electronic produce!

Are we doomed then, like the British at the close of the 19th century, to dissipate our industrial leadership by failure to modernize aging facilities and embark on innovative paths?

In response to the threat from abroad, politicians have begun resurrecting old shibboleths such as "protectionism" and inventing new battle cries, such as "competitiveness."

Nevertheless, despite the politicians, we *are* beginning to make American industry competitive again. This is being done by introducing more automation into industrial production and by better trained workers who are careful about quality.

Robotic production changes in the nature of work. The previous Industrial Revolution had changed the simple handicraft worker to a machine operator. The skill was built into the machine, and a semi-skilled worker could operate it. With the robot performing the manufacturing operation, however, the production worker is no longer a machine operator but a machine supervisor. He sits in front of a control panel looking at dials, while the robot's computerized program actually operates it. The worker's responsibility is to monitor this complex and expensive equipment.

But I am talking as if robotic devices are already the norm in American manufacturing. The fact is that, while they are being rapidly introduced, the current generation of industrial robots are still in a relatively infantile stage of development.

For we have not reached the point where robots can completely replace human beings in the workplace. Although robots can perform repetitive tasks much faster than human beings, they sometimes break down. After all, if all our machines worked perfectly, we would not need repair shops nor "fit-it" people. So we need skilled workers who can back up the robots and maintain their productivity.

In a sense this represents a turnabout of the old assembly line, where the tasks were fragmented, requiring little skill on the part of the worker, and where the planning function was carried on by engineering specialists separated from the physical work. But we overdid the principle that work should be broken down into the smallest operations, and that the worker should not have to utilize any intelligence whatsoever; that system began deteriorating in the 1960s, producing goods that appeared shoddy as compared to imported products, and at higher costs.

We are now engaged in reversing that process, and this reversal is concentrated in industries that produce complex products in vast numbers, such as cars and appliances, the very industries that had earlier been the core of American mass production. Robotization is turning things around--and also changing the worker's role in production.

Although robots are perfect for specific tasks, they are not adaptable to other production operations. Hence the most recent development is a reorientation of the assembly lines to accommodate a combination of the robot and the worker. If factories are to be automated successfully, we have learned that we must also employ the worker's training and intelligence, his mind as well as his hand, in order to handle the more thoughtful and complicated operations of the new manufacturing process.

For example, up until a short time ago, American workers were not permitted to stop the assembly line in order to make sure that quality was being maintained. Now we are trying to improve quality by "group assembly," which started in the automobile factories in Sweden. It makes a team of workers responsible for the entire product, rather than individual workers doing just one little task each. If something is wrong, the workers can push a button and hold things in place while they fix it.

If this works out well--and it has in Sweden and Japan--it will mean that smaller numbers of highly-skilled workers, working with sophisticated, computer-controlled equipment, will replace thousands of semi-skilled workers in today's assembly-line plants. This improves quality control, ultimately reduces costs and at the same time means more satisfied customers and better sales. In a sense, we are making the assembly line more efficient by getting the worker increasingly involved in production decisions.

This new turnabout in automation--teaming together man and the machine--means that we will require more skilled technologists if automation is to achieve its full potential of increasing productivity and reducing costs, thereby enabling us to compete more effectively with foreign companies.

However, the introduction of robotics has all sorts of implications. For one thing it requires new initiatives in industrial education and vocational training. Equally important is the social problem: what are we going to do with the workers displaced by robots? The percentage of workers employed in factory production has been going down, down, down, ever since World War II, while technical advances enabled the smaller number of workers to produce more goods. In 1929, manufacturing employed 45% of our workforce; by 1977, fewer than 25%; today it is down to 17%, and Peter Drucker predicts that by the year 2000, only 10% of the working force will suffice to provide all our material needs. Where will all the unemployed workers go and what will they do?

Well, the Industrial Revolution took people from the farm and put them in factories. Can they go back to the farms now that they are no longer needed in factory production? That is unlikely, and we need only look at the statistics to see why.

At the turn of the century, well over half of the people in our country lived and worked on farms; today, only 2% of the population does so. But despite the diminishing numbers, agricultural production has increased tremendously. In 1910, each American farm worker supplied enough food products for only 7.1 people. But today each American farmer can feed 84 people.

If the displaced factory workers cannot return to ancestral farms, they might go into the service sector of the economy. After all, that sector has been growing rapidly in the past decades, and to put it dramatically, McDonald's now employs more than the U.S. Steel Corporation.

But how many billions of hamburgers can we eat--or, to put it more prosaically, can the service sector continue to expand and take up the slack in manufacturing employment?

Can the making and servicing of computers and the burgeoning service sector take up the resultant slack in employment deriving from automation in the factory and the office? Vassily Leontieff, a Nobel Laureate in Economics, does not think so; instead, he believes that we should spread out the work among larger numbers of people by a shorter work week.

But with the decline of organized labor's strengths and the movement of production abroad, it is unlikely that the work week will be shortened. And even if that were to happen, it is questionable if it would take up the slack from those thrown out of work by factory robots and office automation.

However, I cannot accept the pessimistic view that mass unemployment will be created by automation. Such prophecies are based on the fallacious notion that one can make a major change in only one sector of the economy, while the rest remains static. Historically, things do not work that way. New technologies inevitably create new demands and new opportunities.

At the onset of the Industrial Revolution, the Luddites rose in rebellion against the introduction of new textile-making machinery, which they were feared would cost them their jobs. Well, the new machinery was introduced, and a hundred years later more people were involved in manufacturing textiles than had been employed in the older handicraft system. The reason is that the great increase in productivity by the new machines so lowered the cost of textiles that vast new markets were created, requiring many more textile workers than had been employed in the old handicraft method.

By producing more, better, and cheaper, robotics can create additional purchasing power, increase the demand for new products, and enhance employment in other fields.

While I cannot predict exactly what new lines of employment are going to result, it is clear that in a society which is becoming more highly technological, the effect is to increase the need for greater technical education at all levels, so as to cope with the new devices and opportunities. For the historical record teaches us that advances in technology ultimately produce more employment and increase the material standard of living for all. But the new jobs require more than technical skills: they demand the ability to perceive, comprehend, and communicate effectively. That is what we mean by technological literacy--the linking together of technical expertise with an ability to function with others and to understand how the new technology fits into the society.

In brief, advancing technology, by forcing fundamental changes in the world of work, inevitably reshapes the technical education which we must employ in order to keep us competitive in the world market, maintain our standard of living, and continue to remain flexible and creative in our world of work.

A new and enlarged obligation thus rests upon technical educators at all levels, which is namely to prepare students to live in a society which is saturated with technology and technological issues. For that, we must have teachers who will show our students how they can enlarge their capabilities of hand and brain, and do it in a way which gives them the confidence to meet new and as yet unforeseen challenges at work and provides them with a sense of belonging to a society in which they can meaningfully participate.

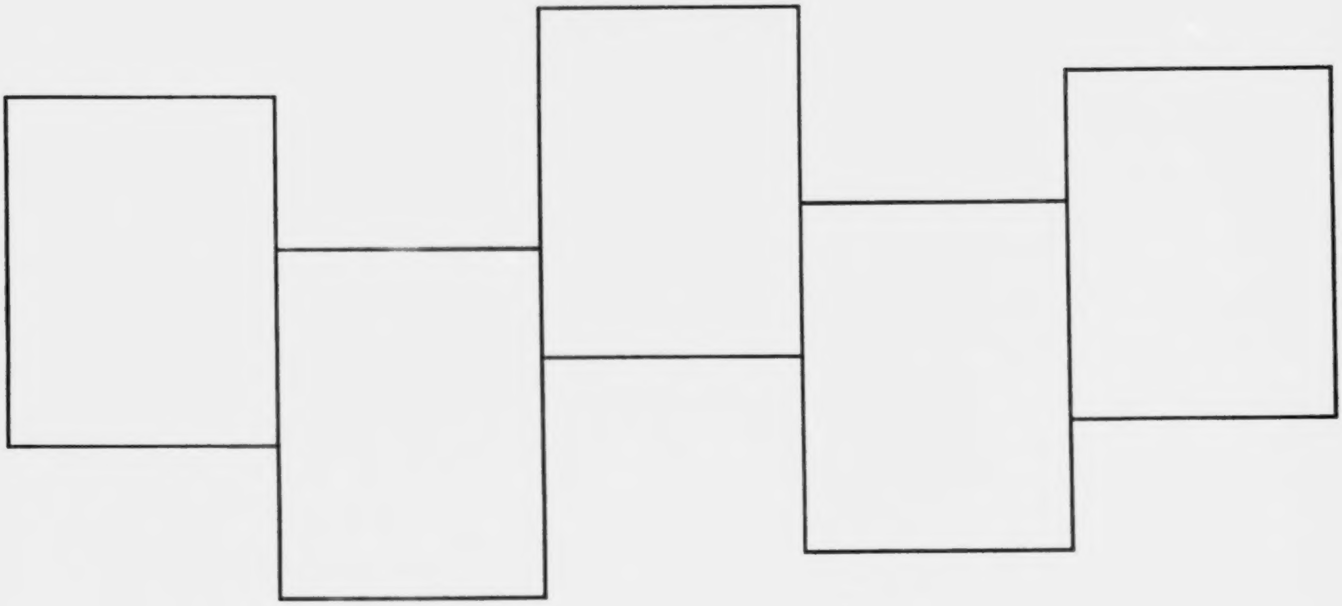
All educators must use their teaching to enlarge the general powers of the mind and inculcate habits of thought that will enable students to face new situations in a rational and creative manner. Technical learning is particularly germane to such endeavors, enabling students to find out the facts, discard irrelevant considerations, figure out possible courses of action to reach a clearly defined objective, and the pros and cons attaching to the various courses of action. So our future depends upon teachers who can bring together both the human and technical skills that are necessary to make our society work properly.

Nowadays I use my students' preoccupation with computers as a metaphor to make them aware of the interaction of human and social elements with purely technical elements. In order to make the computer a useable device we need both "hardware" and "software." The hardware, the computing device itself, is of no use without the "software," which provides it with the data, the programming instructions, the methodologies and the questions as well as the logic to answer the questions. But the software is no use without the hardware and is subject to its capabilities and limitations. We need both--the technical and human elements--in order to make both our technology and our society work better. That is what we can learn from my field, the history of technology, but it also forms part of the technological literacy which will inspire and direct our students when we teach them vocational, industrial arts, engineering technology, and the whole panoply of practical arts.

In this connection I remember a story told about Fritz Kreisler, the great violinst. A lady came up to him after a concert and gushed, "Oh, Maestro, your violin makes such beautiful music." Kreisler picked up his violin (a Stradivarius, no less), held it to his ear, and said, "I don't hear any music coming out of it."

You see, the beautiful music coming out of the violin did not come from the instrument, the hardware, alone; it depended upon the human element, the software. And all technology represents this combination of human ingenuity expressed in the machine, with human needs and purposes in utilizing it. If the machine is imperfect or if the software is faulty, the music which emerges will be discordant. But when man and machine work together for human purposes, they can make some very beautiful music - and that is the meaning and purpose of technological literacy.

Characteristics of Technologically Literate Citizens



Techniliterate vs Technilliterate (There's an L of a Difference)

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This paper will discuss the differences that exist between persons who are technically literate and those who are not. It will discuss the barriers to communication between groups and, finally, will suggest strategies for minimizing these communication problems and a timetable for implementation.

In any discussion of individual differences it is necessary, and dangerous, to generalize. Generalizations trivialize individuality and are subject to exceptions which, in their turn, lead readers to dismiss the generalization. The reader is asked to consider the generalized statement as a possible truism, and to judge it on its merits. It is agreed that exceptions exist for each characteristic identified. It is also noted, however, that the characteristic exists with sufficient frequency to make it noteworthy.

One further caution is made. Throughout this article reference will be made to the technically illiterate individual. This term is not used in a pejorative sense. Recognize the fact that the level of technical literacy lies on a continuum and that the terms *literate* and *illiterate* are used to distinguish between levels of literacy within and between groups.

Technically literate people, and the technically illiterate, belong to widely disparate groups; more widely separated than those who can and who cannot read. The non-reader can, with some effort, hide the inability to read. Indeed, many persons react with shock when it is discovered that a co-worker of long acquaintance is a non-reader. Our society is tending toward a non-reading base where the ability to read is *not* a criterion for success on the job. This is supported by the advent of machine intelligence, voice-prompted computers, cars, vending machines, etc., and the use of pictographs rather than letters or words on the controls of machines and appliances. The technologically illiterate, on the other hand, have nothing to hide behind. When the car won't start, the garbage disposal jams, or the refrigerator gets a wet spot under it, the technologically illiterate are completely out of their element and must rely on someone who *is* aware to solve their problem.

Two interesting side issues occur as an outgrown of this situation. First, the complexity of the device that flummoxed the illiterate came as a result of technological sophistication and, second, the illiterate feels he or she is aesthetically and intellectually superior to the one called to resolve the problem! It is at this point that the "L of a difference" come into play. At the risk of being alliterative, it is time to discuss Labor, the Lord and Lackey syndrome and the Love of Labyrinthian Linkages.

Since the beginning of humanity we have tried to find an easier way to accomplish a task. All of technology has as its premis the accomplishment of more, better, faster and easier. It is here that the word *easier* gets confused with the word *labor.* Our society aspires to an easier job; one that requires less labor. Easier is allied with white collar endeavors, labor correlates with blue collar activity. Thus our society, indeed all of the emerged and emerging nations, aspire to academic pursuits which, it is widely held, have no labor attached to them. These are the easier forms of existence which come as a given for the college and university educated. Have you ever seen an advertisement which, urging the purchase of this insurance policy or that Certificate of Deposit, suggests doing so to provide for your child's *technical* education?

The presumption is that white collar workers do not *labor* at their jobs. Thus the college graduate feels superior to the non-college technician. They feel that they have spent four or more years in advanced academic pursuits and that they certainly have every right to be proud of their accomplishment. They believe it is obvious that their intellectual capacity exceeds that of the non-collegiate. They cannot be expected to know *everything* about the operation of every mundane appliance. Their time is spent with things of higher and greater import!

Someone must be lord and someone else the lackey. Fortunately, they were skilled enough to become the lord.

A linkage is the uniting of two or more entities into one cohesive entity. This new entity may be as loosely connected as a chain or be as tight as a crosslinked co-polymer. The technically literate love linkages. They are thrilled by the process of pulling information from this discipline, and hardware from that discipline, and putting them together to make something that no one has ever thought of before. The more convoluted and disparate the sources used in this process the better. To pull arcane knowledge from chemistry, tie it to some law of physics, apply abstract or high-order mathematic processes, incorporate logic, philosophy and literature to produce a physical entity is the ultimate thrill for the techniliterate. It is just process that brought about lasers and Large Scale Integrated electronic circuitry. The technilliterate, on the other hand, has neither the background nor the inclination to become so involved. Indeed, the latter is the genesis of the former; the lack of inclination is the basis for the lack of ability.

It must never be assumed that the technilliterate is stupid for it certainly is not true for the broad spectrum of the group. Instead, the technilliterate is interested in other things, centered primarily on the manipulation of abstractions. The technilliterate finds great value and solace in words and the feelings they evoke. Their linkages might involve poetry rather than physics, Mahler instead to metallurgy and Existentialism in place of electronics. The key point is not the subject matter but the mindset; the technilliterate feels his or her interests are purer and therefore of greater importance than those of the techniliterate. The technilliterate recognizes the value of technical knowledge, and applauds those who possess technical skills, but relegates this knowledge and expertise to a low status position. Those who engage in such pursuits are commended for their abilities, but are mourned for their lack of dedication to things of value, benefit and importance to the *true* purpose for human existence, that being the elevation of human potential above that of the animals.

The ability to communicate between groups, rather the inability to communicate, is centered on this mindset but has permutations not unlike those that surround a conversation with a born-again missionary. A trip through any major airport will put you in contact with persons possessed by a missionary zeal for their topic. Theirs is not an easy task, for they must present themselves and their subject to someone who is preoccupied with other subjects, under a time constraint, who probably has strongly held convictions about the topic and is suspicious of the motives of the person who brought the subject up. To agree to spend time in conversation requires that the hearer make the commitment to question deep-seated beliefs. Of greater importance, the hearer must be willing to allow the other person to set the agenda; to infringe on his time with their topic. In essence, the accosted person must be willing to take the submissive role and most people are not willing to do this. The decision to listen or not is based on a weighing of alternatives. This subliminal evaluation takes place in a matter of seconds or fractions of seconds and, more often than not, the decision is to avoid the situation, not to listen or become involved.

So, too, is the process of communicating between the technically literate and illiterate. It is easy to communicate within groups; your audience feels as you do and can ascribe all of the communication barriers to the other group. The real problem comes when individuals or delegations from one group attempt to speak with their counterparts in the other group. Emphasis in this last sentence is on the word *with*. Speaking *to* someone is at a more superficial level than speaking *with* someone, and it is this latter that must be attempted and accomplished. We are talking here about the process of communication, actually the diffusion of innovation for the ideas presented may be innovative in the minds of the technilliterate. Rogers and Shoemaker present an excellent discussion of this process in their book *Communication of Innovations, A Cross-Cultural Approach.* Before discussing their book, however, some thought should be given to the participants in the process.

Who should present the information about technical literacy? The speaker should be each of us. The process should be on at least two levels, individual and group, and the hearers should be the opinion leaders in these two different audiences. On the individual level each techniliterate must initiate a planned communication process, presenting our position but in the hearer's language. In their book *Frogs Into Princes: Neuro Linguistic Programming,* Bandler and Grinder talk about feeling tones. They make an excellent case for listening closely to identify the type of phrases other people use to express their feelings, then using these same phrases or their variants to express *your* feelings to them. Simplistically, if a person says "I'm really in a brown mood today", indicating that they are sad and using color symbols to communicate feelings, then your responses should also use color as a means of expressing your feelings and concerns. The point to be made here is that the speaker's sole responsibility is to get the message into the hearer's mind clearly. The hearer has the greatest amount of work to do in receiving the information, converting it into a familiar form, analyzing it and accepting or rejecting what was received. When the speaker presents data in a format familiar to the hearer it is received more willingly and with a greater potential for its being accepted.

The process is not markedly different when communication is inter-group rather than inter-personal. The feeling tone needs to be prevalent, but it must be more generalized than is the case for interpersonal conversations. We must identify the population and sub-group to whom we want to speak, determine the terms and phrases the target audience uses to express its feelings, then use these phrases in communicating with them.

Rogers and Shoemaker identify five groups within any population, categorized as to their willingness to accept innovation. These adopter categories are identified as Innovators, Early Adopters, Early Majority Late Majority and Laggards. Additionally, the authors discuss the social dynamics between adopter categories and provide insight into the rate at which innovations are accepted. The opinion leader in this process is the Early Adopter. The Early Majority look to this person as their model, shunning the innovator because this person is too far out in front of the pack to be accepted or trusted. The Late Majority looks to the Early Majority and the Laggards, being very conservative or adamant in their beliefs, do not accept the opinions of anyone. The Early Adopters are about fourteen percent of a population, but they sway the opinion of the nearly seventy percent in the Early Majority and Late Majority categories. Thus the Early Adopters are a potent force and one whose assistance we should work hard to achieve.

Our first task, then, is to identify the target populations and determine who falls into each category. This is not as difficult as it might seem. Powers developed a procedure, later refined by Tait, Bokemeier and Bohlen, which provides an excellent model for accomplishing this task. Using what they call the Reputational Method, people can be identified, and categorized, simply by asking other people to tell you who these persons are. Ask twenty people to list the names of three or four people whom they believe to be the leading technilliterates in your community. Keep the lists and see whose names occur with some frequency; there is your list. It will probably contain no more than six to eight names, but you may be assured that the list does, in fact, contain the names of some of the leading technilliterates. There will no doubt be others whose names will be added, but you have the starting point for refinement. This process works for any group where membership is known to the public, and for a population as large or as small as you choose to sample. The sample size will be modified as the population base increases, but the process remains unchanged. If the target population is at a professional, social or economic level significantly above or below yours it will be necessary to identify an intermediate population through whom your point can be communicated. It is not possible in this article to provide an in-depth summary of this writing, and it is not as cut and dried as presented here, but it is not a complex process either. Those who are seriously interested in pursuing the communication process should read this booklet or other related materials.

Having done all of the above, identified the audience and its subgroups and determined the feeling tone, what do we have that needs to be said? In the one-on-one conversations we need to communicate the higher order skills that are associated with the learning our students are doing. Emphasize the math and physics, the abstract reasoning, the aesthetic concomitants of what is being taught and learned. Certainly these entities are a part of all our courses. These need not, probably should not, be long involved conversations. Instead, they should be one-liner types of comments, inserted frequently into otherwise normal conversations. If the opportunity is presented in a group session, emphasize the personal growth that has been evidenced in a specific student. Make the point of sending good news letters to parents, and the counselors or pastors of your students. Again, this should not be an isolated, even an occasional thing. It should be a part of your regular student evaluation process. It should happen weekly, not for each student, but certainly for one or more students. Similarly, good news notes can go to the Counselor, Principal or Dean, to support them in positive actions they have taken for you, for your students, or for education in general.

Do not expect these efforts to bear fruit immediately; nothing works that quickly. Be prepared to spend three to five years in the process ofmaking a noticeable change in the perceptions of your target population. It took New Math nearly ten years to be fully accepted, the television set took almost twenty. Indeed, the term technological literacy has been in use for nearly five years and is only now beginning to be used outside a very select and innovative group.

In dealing with the public as a whole we must employ a process similar to that discussed above, but we must employ a communication device that is viewed as important by the technilliterate community. It is this author's opinion that the most potent possible device would be a standardized test for technological literacy.

The academic community has a love affair with standardized tests. From the third and fourth grade, onto the Graduate Record Exam, the academic world is filled with standardized testing. We all grew up with I.Q. and aptitude tests. Our lives and the lives of our students and children are governed in large measure by the scores achieved on one or another standardized test. In Iowa, and many other states, whole school systems adjust their curricular emphases on the basis of district-wide math, social studies, English, reading and science test results. Note that changes are made on the basis of these subjects alone; with little or no thought about the rest of the district's curricula. Building principals and teaching staffs are acutely aware of their school's standing with respect to other schoosl in the district, and their district's standing in state and national norms. The existence of an abstract number, computer printed on a student's or a school district's performance evaluation form, gives credence to these subjects far in excess of their actual value. Indeed, the perceived value of the number, and of the subject matter, support one another in a regenerative manner. It is long past time when technical education drank at the same fountain as the rest of the educational community. For these reasons, and many other unspoken reasons, it is proposed that a three-year effort be undertaken to establish a nationally normed Technological Literacy test or sub-test, to be incorporated into one or more of the nationally recognized educational achievement tests. The inclusion of such a test would bring technological literacy into its rightful place as an item of national importance and concern.

It was a revelation to the author to learn that there is no such test in existence. In December, 1986, contact was made with the National Center for Research in Vocational Education, asking for a listing of any tests in the area of technological literacy. The Center indicated that they had no such tests and suggested contacting Educational Testing Service and the National Occupational Competency Testing Institute (NOCTI). NOCTI exams exist for specific skill areas but none exist that provide a broad awareness of technology. Educational Testing Service was contacted, with similar results. Contact with the head of the Iowa Test of Educational Development (ITED) was negative insofar as the existance of such a test, but positive with regard to interest in such a test.

Many problems must be resolved to accomplish the task of constructing, norming and validating a technological literacy test. Not the least of these will be to *define* technology and develop criteria and a methodology for assessing an individual's literacy. It is suggested that the following definition be considered as a working permis:

Technology is the product, tangible and intangible, resulting from the incorporation of knowledge from two or more subject matter disciplines for the express purpose of developing devices or processes to create goods or services in a quicker, safer, easier manner. Technological literacy is the awareness within an individual of the basic tenets of these disparate disciplines, and the ability to draw from these disciplines to resolve the problems associated with the development and perfection of a concept or device.

With this as a base, it is recommended that the National Center establish a committee to work for a three-year period and whose functions will be to:

1. Define technology and technological literacy in terms that will be sufficiently broad to benefit all facets of technical education, but without becoming so vague that it loses its effectiveness as a descriptor of the domain and the basis for assessment of individual technical awareness.

2. Develop and pilot sample items to be included as a part of a standardized technological literacy test.

3. Work through the Center for Research in Vocational Education to establish dialogues with Educational Testing Service and other assessment agencies for the development, norming and marketing of a technological literacy examination.

In summary, it has been suggested that technological literacy is a distinct entity, separate from the conventionally accepted definition of literacy. The technically literate and the technically illiterate have widely dissimilar views of our world and society, and the technilliterate has a feeling of superiority related directly to their literacy in non-technical areas. As a result of these feelings, communication between groups is stymied and will not improve until some means of communication is found which is seen by the technilliterate as an acceptable form of and basis for communication. On the personal level this change in communication strategies must be advanced by the techniliterate, in terms common to and accepted by the technilliterate. The same conditions apply on the group or institutional level but it is suggested that the communications vehicle be a standardized technological literacy examination or subtest which will be utilized to determine the technical sophistication of large groups of students, ranked according to national norms. The process of diffusing an innovation is a slow process, but one which proceeds along a prescribed and easily recognized process. Given an awareness of the process, and a willingness to commit the time, the process will yield positive results.

Our nation has for nearly 200 years been a world leader in the development and dissemination of technology to the remainder of the world. Yet even the unpracticed eye can see that this preeminence is eroding and that the United States is going the way of England, Rome, Persia and every other predecessor in world leadership. Our status as a technological power is being usurped by emerging countries and countries where technical expertise is viewed as a virtue to be coveted and admired. We are approaching a 21st century Dark Ages wherein only the elite will understand the working of the devices that surround us. The masses will be subject to the wishes and whims of the few, for these few will hold unlimited power over the lives and daily existence of the many.

Perhaps the effort to stem the tide of inevitability is futile, with the end pre-ordained. It is not, however, in this author's makeup to give up without exerting all possible effort to the stemming of the tide. There *is* dignity in the creation of tangible products. Technically literate persons do *not* simply "work with their hands". Our nation and the world needs fewer people as paper generators and more as innovators and producers of technically sophisticated concepts and devices. There *must* be a re-awakening of the American Cup Do spirit, with the attendant pride of accomplishment for those who can *Do*. It is the author's hope that his is not a single voice, crying in the wilderness, but rather the loudest at this moment with others who are willing and able to join in the process of re-acquainting a nation with its roots and its heritage. The establishment of technological literacy conferences is the first step in that process but it cannot be allowed to end when the conferences end. The conferences must begin a dialogue that continues, and expands, to fill the void between this Nation's perceptions and the actuality of technological literacy.

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International Perspectives on Technological Literacy

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Overview

Considerable attention has been afforded the concept of technological literacy--in North America at least. Despite this, we must recognize that there is a tremendous range in the definitions of such key concepts as technology and technological literacy. Why is this? Don't the members of our profession do their homework? Are the terms so new that we are just now defining them? Are others as confused as we sometimes seem to be?

I wanted to address these and other concerns. For example I wanted to see our ideas in context--i.e., against the backdrop of others' thinking. Because I occasionally find our profession to be somewhat parochial, in that we seldom look outside our normal circle of friends, let alone overseas, I thought it would be valuable to see what our international colleagues are doing with these concepts. How are they defining them? How are they using them if at all? What could we learn from them? The approach is similar to Todd's (1986).

However, in addition to the quest for some perspective, I also wanted to test an idea. The idea was that a country's concept of technological literacy (if any existed at all) was positively linked to its stage of development. In essence, this idea is analogous to Maslow's hierarchy of needs. It suggests that when a country's human resource needs are for economic or other survival, then the country's educational policies will not emphasize technology for all. Only after the basic technical skill needs have been satisfied would the country be likely to shift to technological literacy as an important outcome of education.

Finally, prior to launching this investigation it must be noted that technological literacy is being viewed as an outcome of technology education, i.e., education *about* technology. Furthermore, technological literacy is considered to be an essential characteristic of those with a quality general education. Consequently, the importance of having deeper insight into this concept is what provided impetus for the research being reported. As a point of reference, the author's current analysis of the concept of technological literacy, and which was developed prior to extensive overseas contact, is provided in Appendix A.

Procedure

Essentially the methodology employed was that of personal interviews. My sense was that there was just too much opportunity for misinterpretation with paper surveys and other approaches with little or no direct contact between the researcher and the respondent.

However, quality research demands that one systematically sample the population if one wishes to reach some defensible conclusions. Given the huge range of possible respondents, e.g., countries, types of schools, levels of education, role of respondents, and the like, sampling of such a large and diverse population is clearly out of the realm of possibility for a small, informally supported project such as mine.

Instead, the procedure employed was based on self-selection. In essence, it depended on the action of those interested in the issues of technology and education. My logic was that many of the most interested colleagues would be participating in several key international meetings that focussed on the topic. Consequently, I set out to participate in these meetings and to conduct my interviews there. The meetings attended included those listed below. The interviewees are listed in Appendix B. In addition, my personal insights into the European (and some international) situations were enhanced considerably by a one month academic exchange (sponsored by the Carl Duisberg Society and the University of Missouri-Columbia) in West Germany. Ongoing literature searches in the computerized data bases further enlarged the input base for this study.

- The World Congress on Education and Technology, Vancouver, Canada, May, 1986
- The PATT 2 Conference (Pupils attitude towards technology), Eindhoven, The Netherlands, April, 1987.
- The European Common Market Conference on People and Technology, London, United Kingdom, November, 1986.
- The International Vocational Education and Training Association program at the AVA Conference, Dallas, December, 1986.
- The International Technology Education Association Conference, Tulsa, Oklahoma, March, 1987.

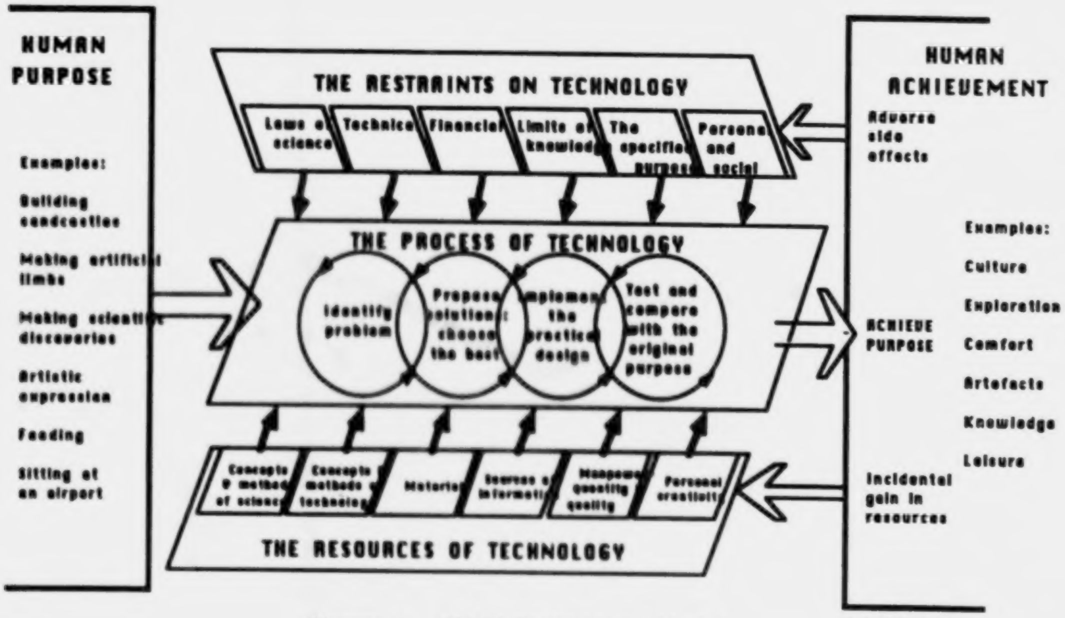
The actual instrumentation was most simple. It consisted merely of a single sheet used to guide the interview questions and to provide a convenient place to quickly record the information that was obtained. This guide provided a structure that engendered a consistency of response that would not have been possible with a mail survey. Soon after beginning the process, it became obvious that the approach was appropriate. Given the difficulties inherent in communicating across cultures, let alone languages, the opportunity to clarify the meaning of questions and responses was invaluable. Furthermore, it often was necessary to explore the respondent's context that housed the perceptions of technological literacy. Consequently, the interviews probed the respondents':

- Country's status with respect to the implementation of technology education
- Description of the nature of any implementation that occurred
- Definition of the term/concept "technology"
- Thoughts about technology's key components
- Usage of the term/concept "technological literacy"

Observations and Findings/Conclusions

The results of my experiences and procedures are presented in Tables 1 and 2 on the following pages. They were recently supplemented by some personal correspondence from M. de Vries (The Netherlands) who has been working along similar directions. It should also be noted that the approach and analytical method employed was clearly impressionistic. Given the nature of this study, it was felt that any numerical treatment of the data would yield a false picture. Similar approaches were employed by de Vries (1987) and Todd (1986).

1. Technological literacy, as a concept, is clearly in a state of flux. It shows some signs of emerging from this early evolutionary stage but for now it remains more a notion than a precise construct.
2. An increasing number of countries are becoming sensitive to the term/concept--technological literacy.
3. It seems that there is considerable agreement that technological literacy necessarily involves an ability to do.
4. The term "technological literacy" is not generally used overseas and consequently it typically is not considered to be the primary outcome of technology education -- although there was little resistance to such a concept once the idea was broached.
5. Little evidence was noted to suggest science literacy was an important topic.
6. More countries are concerned with technology education for all students than are concerned with technological literacy.
7. The US approach to technology education seems to be considerably more developed than that of most other countries. Although, it is clear that rather sophisticated models and programs exist internationally and some even have considerable history, e.g., the English SCSST Model shown in Figure 1.
8. Despite the relatively advanced position of the U.S. conception of technology education and of technological literacy, there are many valuable lessons to be learned overseas. Additionally, the process of trying to understand others' approaches invariably cause one to confront some of our own assumptions and question them as well as recognize alternative configurations that might well have potential for increasing our own effectiveness.
9. The leading characteristic that distinguishes overseas implementations of technology education from ours is their emphasis on design and problem-solving processes as compared to our focus on mastery of technical knowledge and/or skill.
10. If one were to be "hard-nosed" and use the criterion of numbers of students affected, I come to the conclusion that technology edu-


HUMAN PURPOSE
Examples:
Building sandcastles
Making artifici limbs
Making scienti discoveries
Artistic expression
Feeding
Sitting at an airport
THE RESTRAINTS ON TECHNOLOGY
Laws o science
Technica
Financia
Limits o knowled
The specifi purpos
Persona and social
THE PROCESS OF TECHNOLOGY
Identify problem
Propose solutions: choose the best
Impleme the practica design
Test and compare with the original purpose
Concepts & method of science
Concepts methods technolog
Materials
Sources o informati
Managem quantity quality
Personal creativity
THE RESOURCES OF TECHNOLOGY
HUMAN ACHIEVEMENT
Adverse side effects
ACHIEVE PURPOSE
Examples:
Culture
Exploration
Comfort
Artefacts
Knowledge
Leisure
Incidental gain in resources

Project Technology

Figure 1. SCSST Technology Model

cation, i.e., education to develop technological literacy, is much more hype than reality. In most places, technology education is not structurally integrated into the educational systems of the country--despite what evangelical proponents would have us believe.

11. There is however some evidence of an increase in the momentum of the technology education movement. More influential people seem to recognize that in our technological world, our schools must help students develop and understanding of, and capability with, technology.

12. Overall there seems to be a "quick fix" mentality in thinking that one, two or three years of courses could meet the societal need. Very little evidence was found to demonstrate a concern for a spiral curriculum that would systematically build a depth of understanding and capability throughout the school years.

13. The Europeans have also worked out an important rationale supporting the need for technology education. It states that a large part of being educated for the professions is of a technical nature (de Vries, 1987) therefore such education is a valuable service to students.

14. Our approaches seem to emphasize the delineation of objectives, competencies and essential elements to a much greater extent than did overseas ones. Many of the latter programs had difficulty in stating even their most general goals.

15. There remains evidence of gender-based course structures in certain overseas implementations.

16. Eastern block country approaches lean much more to the vocational side than do the British, Flemish or Dutch.

17. Often international science and other non-industrial/vocational educators value technology education more than ours do.

18. It seems appropriate to conclude that we cannot, and in fact we must avoid, the casting of technology education as the 'deus ex machina' of our time. We cannot expect a set of solutions carved out of the political feasibilities of our realities to be as powerful as our conceptual models suggest. In short, we must not oversell the potential outcomes of technology education

19. There are many who "bastardize" the concepts of technology education and technological literacy (less frequently) by "forcing"

what they are currently doing in regular, vocational or other education and passing it off (mislabeling) as technology education or its products.

20. On the technology vs. industrial technology issue, generally my observations suggest that the technology education view has more proponents--it is clearly the preferred term overseas. However, there is also evidence pointing to the use of a general lable, i.e., technology, being applied to what is clearly the industrial subset of technology.
21. Our European colleagues were much more tuned into the nature of the student than what we seemed to be. For example, it is to the credit of Raat and de Vries' project groups, and in fact several others of the PATT research group, that they noted the great difference between their intellectual and conceptualized model of technology and the model that young students have in their minds. The implications of this for instructional practice seem to loom large!
22. Type I and Type II errors. The opportunity for committing either of these seems very high when working on comparisons in the international arena. For example one gets totally different answers when one meets with ministries of labor instead of education. Because of this it is extremely difficult to support generalizations based on what must be recognized as a cursory contact.
23. There is considerable congruence in support of the generic technology clusters of materials, energy/ power, and communication. Transportation, manufacturing and construction are not widely addressed.
24. There is good evidence to suggest the computer is an over used example of technology overseas as well as in the USA.
25. There is a serious terminological problem that must be overcome before survey approaches become feasible.
26. In Europe, much more is made of the technology--technique distinction than is the case in the USA.

Conclusion and Summary

There is much to be learned overseas. The opportunity to be outside looking in yields fresh perspectives that invariably help improve local practice. Overall, Americans can feel proud of the level of their conceptualization of technology education and technological literacy. Now what remains in the USA as well as in most other countries is to implement programs that deliver on the promise!

Table 1. International Summary: Technology Education Implementations

1. Has your country implemented a general education technology education course/program?

• For all students?	• For some students?	• What are its main goals?	• What grade/age levels?	• Is it voc ed or general ed?	• Is it required or elective?
England					
About 10-20%		Craft/Design/Technology	Ages 14-16	Mainly for general education	
About 20-30%		Craft(Shop)	Ages 11-14	Mainly for general education	Required informally, generally for lower ability students
Yes, but not in all localities. Under local control			K - 12		
India					
Scotland					
Technological Studies is to be required as of Aug 1988		Develop problem-solving skills, apply systems approach, comprehend evolution of technology and recognize the effect of technologyon the quality of life and theenvironment, to highlight role of technology in manufacturing	Age 14-16, boys & girls	General education	Elective, for two years, 160 hrs during these 2 years
Some Science & Technology					
		Removes some of the design emphasis from CDT as compared to England			
Australia					
Little movement toward technology education					
Nigeria					
Little movement toward technology education	Introductory Technology. Pupils can choose 2 of 4 subjects, and this is one of the options but both boys and girls can take it	Prevocational, work orientation, some life skills, stimulate creativity	Ages 11-13, grades 7-9	More prevocational than general	Elective
Spain(Catalona)					
	There is a subject called Technology but it is still in the experimental stage (de Vries)	General development and to help understand the modern world (de Vries)	Ages 12-16	General education	Experimental
Austria					
None	Yes, "Werkerziehung" (work education) • girls get textile version • boys get technical version	Craft & skill oriented			Seems prevocational
Canada					
No widespread implementation					
Denmark					
Not in 'Folkeskole' (primary education, grades 1-9) (de Vries)		The subjects offered here; needlework, craft & design, home economics, art sciences and creative art; are more craft oriented than an introduction to technology (de Vries)			

Table 1(continued). International Summary: Technology Education Implementations

1. Has your country implemented a general education technology education course/program?

For all students?	For some students?	What are its main goals?	What grade/age levels?	Is it voc ed or general ed?	Is it required or elective?
Portugal					
Somewhat, quite . recently but technology is not in the compulsory part of general education. After the political change in 1974 the technical schools were suppressed in order to engender equality. In 1983 the technical schools were re-launched.	Technology education is attached to technical & prevocational education			In 5th & 6th grades "crafts" is incorporated and this includes a module on technology	
Poland					
Yes, Crafts and Work-Technology (in 'Liceum', i.e. general education)		Some theory, make project	Grade 1(secondary) grades 4-8, 2 hours/week, visit industry Related to work in industry	General education General education (ages 15-18)	required required
Kenya					
Arts and crafts		Electricity, leather, cooking	Primary schools		
	Industrial Education Technical schools were removed and shifted to Technical Colleges	Since 1985 the government has moved to emphasize the practical aspects but there is not a specific Technology course required. The approach is via the infusion of technological content into Industrial Education's lessons.	Age 14-18	More vocational than general	Elective
Mexico					
Yes, technological education, but it is more on paper than in schools		To get people into jobs therefore it is not really technology education in the sense we are using the term here.	Secondary		Required. After first year of sampling, students choose among unit courses
Hungary					
Technic was introduced in 1978, for boys and girls		Meaningful occupational career choice. Deals with everything of our material environment, to develop coordination. Curriculum is different in rural and urban areas. Former emphasizes agriculture, the latter wood, metal, drawing and electro-technic	Grades 1-8, required in grades 9-10, elective in grades 11-12	General education	Grades 1-8, required in grades 9-10, elective in grades 11-12

Table 1(continued). International Summary: Technology Education Implementations

1. Has your country implemented a general education technology education course/program?

• For all students?	• For some students?	• What are its main goals?	• What grade/age levels?	• Is it voc ed or general ed?	• Is it required or elective?
Belgium					
Yes, Technological Education Because all other components of life had subjects in school (except for technology) they had to make room for this in the curriculum		The culture and environment, this includes technology. To develop capability with the technological process: • Problem statement • Purpose description • Brain storming • In-between design • New structure actualizing • Evaluation intermediate evaluation occurs after each step) General development goals	First class, ages 12-13, 2 hours/week Second class, ages 13-14 2 hours/week	Definitely general, Eg. Components of life/culture: • Verbal/literature • Ethic/religious • Exact/scientific • Human/scientific • Musical/artistic • Technic/Technological	2 hrs/week are required, an additional 1, 2, or 4 hrs are elective 2 hrs/week are required, an additional 2 hours are elective
				Note, Technics/Technology also exists at the technical school:	• Theoretical subjects 4 hrs/week in first year, 6 hrs/w in second year • Practical subjects 6 hrs/w in first year, 8 hrs/w in second year
				At vocational school:	• Theoretical subjects 4 hrs/week in first year, 6 hrs/w in second yea • Practical subjects 6 hrs/w in first year, 8 hrs/w in second year
Yugoslavia					
There is a separate subject, called Technology Education also there is a subject called Work at Home		Orientation to future work	Grades 4-8 and 2 years of high school		Required, boys & girls
			Grades 7 & 8		Required, boys & girls
Finland					
Not really, the closest is Craft Work. New technologies are incorporated into crafts. (de Vries)	Craft is divided into: • Technical work for boys • Textile work for girls	Skill oriented	Grades 1-7 Grades 8-9	More and more "bright" students are taking Technical Work because school is too theoretical	Required Elective
France					
At the collège (JHS) technology is required, for boys & girls		General development	JHS	General education	Required for 2 hrs/wk plus elective for 3 more hrs/wk
	At the Lycée (senior high) it is optional (de Vries) but mainly boys elect		SHS	Prevocational in nature, many specialized subjects (de Vries)	Elective
Federal Republic of Germany					
Several implementations exist as "Länder" have autonomy				General education, i.e. prevocational	Depends on which "land"
• Arbeitslehre in Hauptschule • Technic in Reale Schule • None in Gymnasium	Some implementation of PolyTechnics and Informatics	Introduction to the economic and work world, links Technic and Home Economics,			
Turkey					

Table 1(continued). International Summary: Technology Education Implementations

1. Has your country implemented a general education technology education course/program?

For all students?	For some students?	What are its main goals?	What grade/age levels?	Is it voc ed or general ed?	Is it required or elective?
United States					
Started but not systematically implemented across all states and communities	In some places				
Netherlands					
Yes, in process of installing technology education as a requirement					

Table 2. International Summary: Technology & Technological Literacy

2. What is the meaning of the term/concept "technology"?	3. What are technology's major units/sections/components?	4. Is the term "technological literacy" used in your country?	5. What does the term "technological literacy" mean to you?
England			
The deliberate application of human creativity, endeavor and knowledge to solution of problems linked to the physical needs of individuals of social groups.	Information, materials, energy, design, problem solving, creativity	Never heard it used	Strong connotation of being able to do! Problem-solving is in any "literacy"
The identification of the needs of man and the endeavor to satisfy these needs by the application of knowledge and the use of materials, resources, and energy.	It is primarily concerned with problem-solving.	Yes, it is becoming more widely used. and most educators would give you a definition	Interaction between science, technology and society. The problem is that most would leave it at the level of intellectual debate only. To be technologically literate one must have experience and practical competence, there must be a "doing" element to it!
			Technological literacy is a subset of technological competence. This link, the relationship between science and practical realization, ought to permeate the whole of schooling
India			
The total knowledge and skills available to any human society for industry, arts and sciences, etc. It is that branch of human knowledge which deals with the industrial arts. It is that part of applied science which has commercial value. It is a balance of knowledge and invention. It takes us forward like a scientist as contrasted to a technician.			
Scotland			
Not defined. This would "nail down" the term inappropriately.	Electronics, mechanisms, pneumatics, manufacturing, systems approach, communication, product analysis, energy, structures	Yes but imprecisely	The use of vocabulary associated with technology. Does not include the use technology.
Australia			
Nigeria			
	Drawing, equipment and materials, identification and processing of materials, use of tools, energy, basic ideas of electricity, magnetism, levers, wedge and screw, food storage, pneumatic devices		
Spain(Catalona)			
	Physics, chemistry, math, drawing, language, history n.b. there is some doubt about how well the respondents understood the survey (de Vries)		
Austria			
	Technical studies involve the components: Building/living, machine technology, production design		
Canada			
Something that is applied, practical, not to theoretical	Design, not too much emphasis on value judgements	The term is used occasionally by those in adult education	Vocabulary pertaining to technology and computers, management systems and terms, hardware and software.
Denmark			

Table 2 (continued). International Summary: Technology & Technological Literacy

2. What is the meaning of the term/concept "technology"?	3. What are technology's major units/sections/components?	4. Is the term "technological literacy" used in your country?	5. What does the term "technological literacy" mean to you?
Portugal			
Not well defined. Very individualized. Not systematically developed.	N/A	Not typically used	Aptitude, energy, how things work, Humans interacting with machines and information
Poland			
The concept of, and a technical project as a fruit of the concept; technical technical processes, technical applied science. There is no consideration of man or practical things as a part of technology.	Culture and organization of labor, materials science, process engineering, technical equipment, technology and management, orienting to a profession.	Occasionally one reads about it in an article, Eg. Friedrich Rapp (Berlin)	Knowledge of technology, not manipulative skills. Skills are technique and this is differentiated from knowledge.
Kenya			
Technology is designing and making solutions to man's problems		Hardly	Widespread knowledge about handling things man-made. To train
Mexico			
Scientific knowledge translated into a product (including bio-tech)	Mainly woodworking, typing, binding (unit courses)	Typically not	Knowledge, every aspect of technology, practical, conceptual
Hungary			
Only industrial processes, Eg. working with iron and materials. We differentiate between technology and technique. The latter is everything around us, it involves designing and problem solving.		Some use it as knowledge about technique, i.e. technique literacy	Knowledge about technique that includes capability with technique
Belgium			
	Communication, energy, living, textiles, food, commerce, hygiene/nursing, technic/technological Recently the schools' program has been narrowed to communication, electro and information, mechanical, energy and living technology	No	To be capable of facing a problem, to see a problem, to think about a solution, to find a right solution, to have it done or to do it yourself.
Yugoslavia			
It has two meanings • something like science • more practical, involved with machines		No	Unable to communicate
Finland			
Tradition is to use it as engineers do, i.e. with narrow meaning, Eg. wood & food technology. Changing the existance of materials, the basics of production.	Woods, machines, energy, craft, metal work, electricity/electronics, technical drawing, production	It has been used in some articles about trends in schools. The concept has been used but not with the same terms.	Most important element is introduction/awareness of new technology, how to use knowledge, the materials, know languages of technology, technological literacy is connected with leisure, recreation, daily activities, home activities, consumerism, cultural/historical stages.
France			
Federal Republic of Germany			
There are many varied perspectives. Technic is used, typically it refers to Industrial products, computers, all "new stuff" Eg. lasers, not telephone.		Typically not, but Kultur Technic is used to refer to reading, writing, and calculating	Technic, the use of technology as we do numbers and letters. It was difficult to even translate the concept into German. perhaps the word "wahrnemungsfähigkeit" is the closest we can come?

Table 2 (continued). International Summary: Technology & Technological Literacy

2. What is the meaning of the term/concept "technology"?	3. What are technology's major units/sections/components?	4. Is the term "technological literacy" used in your country?	5. What does the term "technological literacy" mean to you?
Turkey		A small number of people use it but typically not.	It is a large concept, ranges from making use of the simplest technical devices to the most sophisticated ones. The ability to make good use of existing technical means, also attitudes towards putting such means to good use, working to come up with even better use.
United States			
the Netherlands			

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Appendix A

A Model and Rationale for Technological Literacy

Technology

In the introduction to my first monograph on this subject, I stated that "technology has been with us ever since we began to manipulate and seek control over the environment" (Dyrenfurth, 1984, p. 1). Although in dicative, this statement falls considerably short of definition. In fact, I question the wisdom of attempting to establish the concept's meaning definitively. Although absolutists' value such effort, I would submit that it is infinitely more useful to characterize the concept by highlighting the features and characteristics that are essen tial to establish the concept and differ entiate it from others. Then, rather than sitting around and haggling over nuances of meaning and definition, we could get on with our work to help future generations harness the concept and design programs to achieve our objectives.

Not only do I deem it more important to work on application, but I also suggest it is more feasible. Given the scope of large scale concepts such as technology, there may very well exist limitations on our ability to evolve an ultimate definition. In essence, observation of social science would suggest that large scale concepts are affected by a principle analogous to Heisenberg's uncertainty principle--namely that there will always be a residual unknown or an element of confusion. Like my scientific colleagues, I submit that definitions based on a probability model offer much advantage and that they allow us to focus on our primary responsibility--i.e., the education of future generations.

What then are the elements, essential features and characteristics that operationally define technology? Which seem to have the highest probability of being essential to the concept's definition? Well, at this stage my work is not very far along, considering the ground that must be covered, but it would seem the following characterize technology well:

- Technology *practices* in order to test or refine theories of efficient action which can only be derived from practice. *Knowledge* (ology) of *practice* (techn) is technology (Lux, 1983, p. 1). It is praxiological knowledge--the knowledge of practice!
- Technology [is] . . . knowing *how* to do something from the rules, sometimes from scien tific theories, sometimes from pragmatic experience

(technic) (Smalley, p. 20).

- Technology is a social process in which abstract economic, cultural, and social values, shape, develop and implement specific artifacts and techniques that emerge from the distinct technical problem-solving activity called engineering which is embedded in that process (Cutcliffe, 1981, p. 36).
- Technology is made up of physical elements invented or created by human beings (DeVore, 1980, p. 3).
- Technology is the creation and utilization of adaptive systems including tools, machines, materials, techniques and technical means, and the relation of the behavior of these elements and systems to human beings, society, and the civilization process.

Furthermore, it is important to note that the concept of technology is used in several ways, the following are but two of the more frequently used ones:

- As a discipline, the term technology denotes a field of study in the same way that geology, biology or anthropology are used.
- As a system, technology refers to a purposefully organized collection of hardware and soft ware used to achieve a desired end.

Technology is also housed within the larger environment of human endeavor. Some key categories of such endeavor are depicted in Figure 1. This model provides a background that could be used when restricting the scope of development work to one of the arenas of technology. Although each has unique attributes, these tend to blur near the interface of two or more endeavors. As evidence of this, consider the difficulties along the interface between religion and philosophy, science and technology, or even social science and technology. However, we must not avoid consideration of the matter just because things are not clear or because they are particularly challenging. It just mean that we must work longer, harder and smarter!

The Concept of Technological Literacy

Two components are essential to the concept of technological literacy. The first is technology and the second is literacy. The former, i.e., technology, has been addressed in the preceding section. Literacy however was not.

Today, at least in the American culture, the term

Figure 1

The Context of Technology

Human Endeavor	Characteristics	Application Arenas
Religion	Divine wisdom	Theology • •
Science	Explanation of nature	Chemistry Physics • •
Technology	Doing, applying rules and experience in solving practical problems	Annihilation Healing Industry Agronomy • •
Philosophy	Systematic thought	Metaphysics Epistemology Logic Ethics • •
Social Science	Behavior	Sociology Psychology Pedagogy Andragogy Anthropology • •

Note: A preliminary and tentative view of the context of technology is shared in this illustration. It presents a series of categories of human endeavor in the left column. The key characteristic(s) of each endeavor is(are) listed in the middle column. Finally sample application arenas for each category of endeavor are listed in the right column. In each column, the items listed are intended to be illustrative rather than exhaustive.

literacy has evolved considerably beyond merely knowing letters--just as its twin, numeracy, means more than just knowing numbers. The 1970 Harris poll showed just how far the public's view of literacy has evolved beyond that of reading and writing. It showed that literacy had come to mean: "the ability to respond to practical tasks of daily life" (p.10). But, is there a more statement about what it means to be literate? The best I have found is Luehrman's claim that:

> Literacy . . . means the ability to read and write, that is, to *do* something with a language, not merely to *recognize* that language is composed of words, to *identify* a letter of the alphabet, or to be *aware* of the pervasive role of language in society. (Cited in Benderson, 1983, p.5)

Analogously, technological literacy *necessarily requires* the ability to *do* technology, that is, to use it and not merely to *recognize* technological processes. Technological literacy requires more than just the ability to *identify* technological components or to be *aware* of technology's effects. Although these characteristics; rec ognizing, identifying, and awareness; are important and necessary characteristics of technological literacy, *without the ability to do*, they are unfortunately *not* sufficient.

Technological literacy is the possession of a broad knowledge of technology together with the necessary attitudes and physical abilities to apply the knowledge in a safe, appropriate, efficient and effective manner. Technological literacy requires that one be able to perform tasks using the tools, machines, materials and processes of technology.

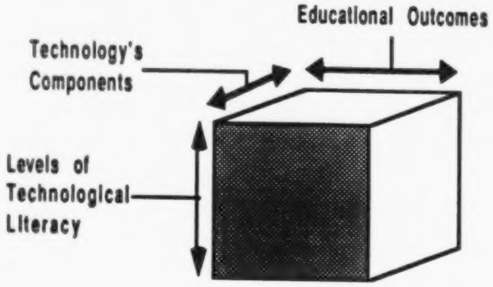
Based on this and my research, I have synthesized a model for technological literacy that I am proud to share for your consideration. Figure 2 presents a simplified introduction to the model and subsequent sections of this paper will provide additional details. Essentially the model proposes three key dimensions which define technological literacy and which guide programming for it. These dimensions are:

1. Technology's components. This dimension is defined by the results of a systems analysis of what technology is and how people "do" it.

2. Desired educational outcomes. This dimension is used to detail the nature of the outcomes deemed desirable by education within the context of our societal needs.

3. Levels of technological literacy. This dimension recognizes that technological literacy is not a singular concept but rather that it can be manifested at varying levels based on a person's stage of development and his/her role in life.

Figure 2
Overview of Proposed Model of Technological Literacy



Fallacies and Perversions Associated with Technological Literacy

1. Technology and science are the same
2. Technology is applied science.

   Kranzberg, certainly one of America's leading scholars of technology, acknowledges that while cases exist which might suggest this, he would dispute the necessity that this be true. At the Chicago Museum of Science & Industry's fiftieth anniversary he stated: "For much of history, science and technology were two separate activities carried out by different communities who rarely came in contact with one another; they used different methods and sought different goals" (1983, p. 8).

3. Computer literacy is the same as or better than technological literacy.

   Far from it! Computer literacy is < technological literacy. Computers are butone part of the technological species. Technology is not a part of computing, rather computing is an aspect of technology. Given this relationship, the concept of technological literacy necessarily subsumes computer literacy.

4. The impetus for technological literacy originates among the ranks of the liberal arts.

   In America, the earliest form of collective argument for technological literacy known to me stemmed from the industrial arts profession. It began with the publishing of Warner's earlier began with the publishing of Warner's earlier work; *A Curriculum to Reflect Technology* (1965). Then the field's references to the topic increased rapidly. Most of them significantly preceded the attention of our science and liberal arts colleagues. Frankly, in our country, the bulk of scientists and their liberal arts ilk just did not deem the study of technology important *until* the force of public opinion resulting from the weight of several generations of neglect loomed so large that they simply could no longer ignore it.

The Significance of Technological Literacy

Technology is the essence of the economy of what we call "developed" countries. Absence of technology leads to our euphuism of "developing" country. Not only does technology play a pivotal role in our economic world, it also determines the extent to which we can defend ourselves and in a large part, the level of our *quality* of life. It is a significant focus for the recreational activity of millions and the cornerstone of a healthy future. Because of its acknowledged importance, technology carries with it considerable responsibility and even threat. Misuses of technology are well known to even laypersons and more than a few knowledgeable experts have forecasted doom precipitated by humankind's use/abuse of technology. Therefore, "it would seem that the hope for a future in which people are in control of their environment lies in universal technological literacy, or the ability to do and to use technology--not just to be aware of it" (Dyrenfurth, 1984, p. 1).

Unfortunately however, human resource development in the technological realm has been termed "our most neglected asset" (Schaum 1981, p. 39). Technology feeds on imagination, audacity, science and most importantly, on technology itself. In order to accomplish the latter, a large proportion if not all of our societies need to be relatively competent with technology. Technological literacy is the foundation for such competence.

Additionally, technological literacy is the basis for flexibility in the future. It enables people to control and evaluate technology, to adapt to the changing world and to contribute to the advancement of its capabilities (Stashak, 1981, p. 23). Gibbons (1983) and Blankenbaker (n.d.) augment this list by suggesting that technological literacy increases entrepreneurial capacity, helps people make more informed occupational choice, contributes to better citizenship, enhances consumer and personal effectiveness, and enables better defence.

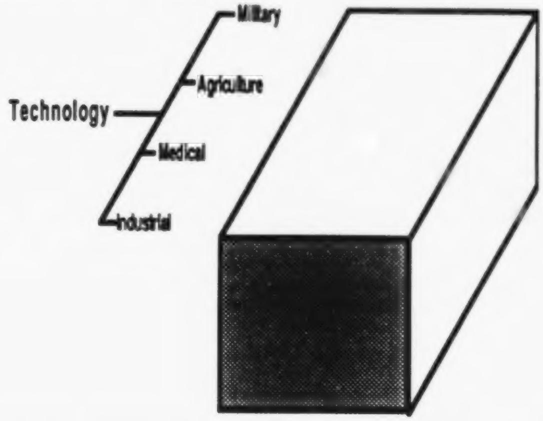
Because of the apparent validity of these arguments, and/or the force of the accumulated technological press, technological literacy is now increasingly considered an essential component of what is being called the new liberal arts. Progress is also noted in secondary education where both Goodlad's (1983) perceptive study of schooling and Boyer's (1983) report to the Carnegie Commission for the Advancement of Teaching call for technological literacy by name.

Technological Literacy: A Detailed Look

Technology operates in many arenas. Although industrial applications may come to mind first, medical, military and agricultural technologies quickly follow. And these are but some of the arenas! I began the development of the model for technological literacy by considering the dimension I labeled, Technology's Components. First I pursued application arenas as further descriptors of this dimension. Figure 3 depicts the model that resulted.

Figure 3

Technology's Application Arenas

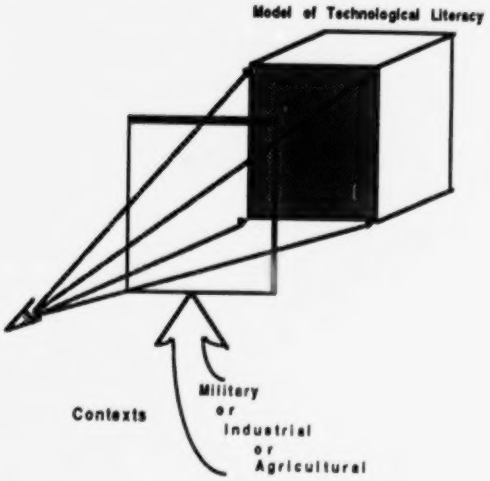


Closer examination however revealed that in each of the application arenas, the process of "doing" technology is quite similar. Consequently it became desirable to treat the application arenas in another manner. Because each engenders unique perspectives, I decided to consider the application arenas as a context or frame of reference through which the model for technological literacy is viewed. This approach is illustrated in Figure 4. These perspectives can serve as screens through which the model can be seen. This removes the settings/application arenas from the model itself and thus makes it more generic--and I hope, more adaptable to the cultural contexts of your various countries.

Figure 4

Technology's Application Arenas as Frames of Reference

Further justification for this treatment of application arenas comes from the observation that each arena's technology typically uses information, energy and processes material. Granted the combinations and some specifics may be unique, but in my judgement the commonality far outweighs the uniqueness. Consequently it seems possible, even desirable, to evolve a model for technological literacy that is not application arena specific.

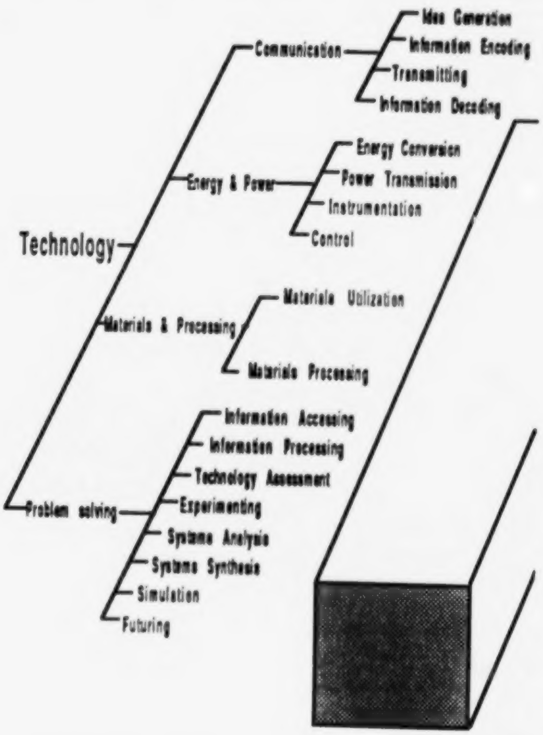

Model of Technological Literacy
Contexts
Military
or
Industrial
or
Agricultural

But be careful! Without the use of a specific arena designator technological literacy must necessarily re fer to literacy across multiple application arenas--not just one or two that might serve the proponent's whims best. Given this approach, which focuses on the generic activities and characteristics of technology, one might now depict the first dimension, that of the components of technology, as shown in Figure 5. This dimension presents the results of my personal analyses which suggest the centrality of four generic activities; communication, energy and power utilization, materials and processing, and of course, technological problem-solving; to all technological endeavor. Additionally, the illustration shows a tentative proposal for the next deeper level of detail for each of the four generic activities.

Figure 5

Technology's Components

Now let us turn our attention to the proposed model's second dimension, namely educational outcomes. What do the schools seek to accomplish? In attempting to address this question, in the late fifties the American Psychological Association developed a rubric, shown in Figure 6, that postulates three domains for such outcomes: The cognitive, the affective and the psychomotor.

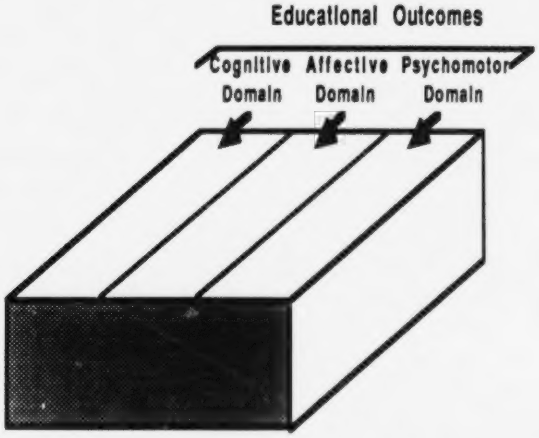

Technology
Communication
Idea Generation
Information Encoding
Transmitting
Information Decoding
Energy & Power
Energy Conversion
Power Transmission
Instrumentation
Control
Materials & Processing
Materials Utilization
Materials Processing
Problem solving
Information Accessing
Information Processing
Technology Assessment
Experimenting
Systems Analysis
Systems Synthesis
Simulation
Futuring

- Cognitive outcomes essentially include those that pertain to reasoning. They range from the most simple, that of rote recall, to the most complex, that of evaluation, in six steps.
- Affective outcomes are those that focus on our students' values, attitudes, preferences and inclinations. They range from the most basic, that of receiving, to the highest, that of characterization, in five steps.
- Psychomotor outcomes are those that involve students' abilities for controlled muscular movement and the intake and processing of sensation.

Essentially the view is that although each domain may be treated separately for analytical purposes, the student typically integrates all three domains as he/she develops each significant new capability. However, the relationships of the domains to one another are not yet well established. Within each domain, mastery of higher level competencies necessarily requires mastery of all lower levels.

Figure 6

Educational Outcomes

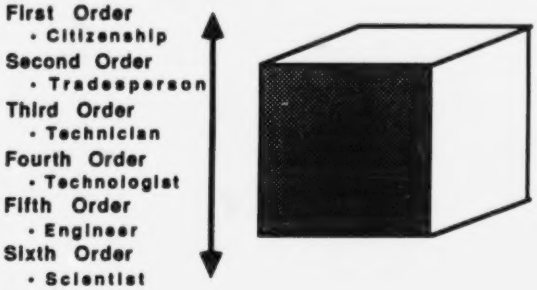


Finally we need to turn to the third dimension of the model, namely the levels of technological literacy. Given the scope of technology, the various purposes of education, and of course individual perspectives, it seems appropriate to consider the existence of varied levels of technological literacy. Consequently I am exploring the implications of levels of technological literacy such as those shown in Figure 7. In essence the level dimension addresses the individual's age, experience, needs, role and the like.

Figure 7

Levels of Technological Literacy

Combining the three dimensions as detailed, together with the use of application arenas as frames of ref erence, results in the comprehensive model for technological literacy as shown in Figure 8. Note also that this model was supplemented with illustrative examples of characteristics that depict educational outcomes in each of the three domains; cognitive, affective and psychomotor.



The following steps are but one approach that may be used to apply this model to the development of an educational program that develops the technological literacy of its charges. Therefore the author cautions his readers not to restrict themselves to this one example of the model's application. There may very well be other purposes for this model and other methods by which it may be used to address them.

1. Begin by asking, with respect to any of the statements on the model's front face, and the first component of technology (Problem Solving), given this outcome:
   - What cognitive capabilities must students have in order to be able to do this?
   - What affective capabilities must students have in order to be able to do this?
   - What psychomotor capabilities must students have in order to be able to do this?
2. Then, still focussing on this statement, repeat the process for the second (Materials & Processing) and each successive component of technology in turn.
3. After completing steps one and two, continue these interactions with each successive statement defining technological literacy.
4. When finished, you will have built a comprehensive description of capabilities that define technological literacy given your particular context.

Summary

This model has been presented for your use and consideration. It is in an ongoing evolutionary state and it should not be considered as being finalized. Additional detail is needed, particularly in augmenting and/or further delineating each dimension with greater precision. Additionally the fifteen education outcome statements that characterize a technologically literate person certainly need to be supplemented. Of course much work also remains to be done to specify how the characteristics of second order technological literacy differ from first and third orders and so on.

Your participation in this quest and in other ventures stimulated by this model is encouraged. The next generations need our work now!

Appendix A
Characteristics of Technologically Literate People

Cognitive Domain

1. Awareness of key processes and their governing principles? (What is it and how does it work?)

2. Understanding of essential relationships among key areas of technology.

3. Ability to conceptualize how an unfamiliar technological process or machine operates.

4. A sense of personal limits (when to call in an expert).

5. Familiarity with technology's efforts on individuals and society.

6. Ability to evaluate a technological process or product in terms of personal benefit as a consumer.

7. Insight as to the relationship between careers and the technological future.

8. Ability to project alternative futures based on technological capacities and applications.

9. Knowledge of technological information assessing methods and sources.

10. Etc. . .

Affective Domain

1. Comfort with basic technological hardware (willingness to use tools, machines, and materials).

2. Imagination to apply existing technology to new problems or situations.

3. Ability to evaluate a technological process or product in terms of personal benefit as a consumer.

4. Ability to choose among technological alternatives in daily life.

5. Etc.. .

Psychomotor Domain

1. Ability to use technological artifacts (tools, machines, materials, and processes) commensurate with one's stage of development.

2. Ability to use technological artifacts (tools, machines, materials, and processes) commensurate with one's role in life.

3. Etc. .

The bulk of this content was presented at the PATT 2 conference, Eindhoven University of Technology, April 1987. It represents a refinement of concepts originally published in Dyrenfurth, 1984.

Technology & the Liberal Arts: Are We Producing Technopeasants?

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Introduction

First, let me say how pleased I am to be able to contribute to this volume and to thank Dr. Blankenbaker and Dr. Miller for having organized the conference and for having invited me to contribute. I am most pleased to be able to do so. This conference and its proceedings address mainstream issues for our generation and most probably the next. These issues are international in scope, and important in a transformational sense.

I have for the last four years been involved in several major projects and programs which deal directly with the issues of technology. I have written, spoken about, produced symposia and subsequent volumes concerned with technology and its multifaceted linkage to our society in general and the liberal arts in particular. Trained as a psychologist and psycholinguist who is interested in the problems of human memory, I know that George Miller told us that we can really only remember seven plus or minus two items, but that George Mandler later revised that estimation to about five plus or minus two, but I'm sure that the real figure for me, is probably one, plus or minus three. What I mean by that remark is that I sometimes have the feeling that I can remember something, but it turns out that what I know or remember is wrong, it makes me think something which is patently misleading. I think this statement is true for much of what is said and written about technology today, especially its role, if it has one, within the liberal arts. I think that the informed citizen "knows" about technology and much of what he or she "knows" is wrong, or misleading. Moreover, I think that some of the misleading and false knowledge that abounds produces and interacts with attitudes, sentiments, feelings, and orientations which prevent and discourage the acquisition and subsequent use of technological knowledge.

Culture, Society & Technology

I want to make several general observations about the nature of technology, together with several far more specific assumptions. Let me begin then with the general assumptions. The first of these assumptions deals with a metaphorical understanding of our society. I want to suggest that at least metaphorically, if not literally, our culture has as one of its primary hallmarks technological knowledge. A flippant way to say this is to say that we live in an electromechanical, digital, computational, chemical, biomedically engineered society. If our society has a signpost, then the signpost is pointing toward technological solutions, toward increased technological knowledge, toward increased interaction with technology, and not in any other direction. It is probably true that only three other cultures seem to be on this same road, and they are Japan, Germany, and France. One could also include Great Britain, but I haven't for reasons of scale. Of course other cultures want to advance technological knowledge, use technological knowledge, and much has been written recently concerned with technological transfer.

David Billington, Professor of Civil Engineering at Princeton, frames the statement another way. "Without modern technology there is no modern life, and no teaching of values in modern life makes sense outside of the context of modern technology." The writers (Schumacher, E. F., 1973; Shi, D., 1985) propounding "small is beautiful" or "less is more" are being sensitive to individual reactions which may be characterized as being "overwhelmed by the wave of technological advances." I want to maintain here that neither these characterizations, nor the wave of technology, is without its price. Careful analysis of these costs seems crucial to understanding what all the fuss about technology seems to be. The fuss seems to be that many people, ordinary citizens and leaders and managers alike, do not know much about technology, do not have much technological knowledge, and do not want to be associated with the forces associated with those that do.

Let me try to be clear about what I think technology is, and how I classify it. Some classify it as merely engineering, and the principles which lie behind, or underneath, engineering thought. Endemic to these kinds of definitions lies a thought process which centers on design, and its constraints of economy, efficiency, elegance, and risk. However, I think this kind of definition is only partially correct. I think that kind of definition somehow ignores the idea that technology is a body of knowledge which is distinct, and apart from other bodies of knowledge such as science. It is first and foremost, not accurately described as merely applied science. Historians of science have produced enough examples demonstrating that good technology, innovative technology, seems to precede, rather than follow, accurate scientific understanding. This "time" distinction is an important one. The notion that science leads, and technology follows inclines one to think of technology as the step-sister of science, the second-child, whereas in many cases cited by Brittain (1984), Kranakis (1984), and Layton (1984), the technologist produces an artifact and then science explains why it works as it does. This is amply true of the machines of medicine that I will mention shortly. This step-sister labelling carries with it certain pejorative attitudes, prevalent and rampant in our educational system today, from grade school to graduate school.

A student of mine, Andrew Henderson, has noted that we begin early in ignoring teaching the mind to think mechanically, innovatively, spatially, and derivatively. He indicts our educational system from the very start. He points out that the culture expresses our lack of esteem for these mentally vital skills. What he seems to be saying is that this is probably a developmentally linked process of mental acquisition which we as educators and citizens are now routinely ignoring.

And so we can say that American society is steeped in a hot bath of technology, governed and directed by a new body of knowledge, but it seems not to be by design of the educators, and indeed, it might be to many's chagrin. Now many Americans, including some of us, feel discomfort, uneasiness, alienation or fear, rather than a relaxed, soporific, somnolence. The mention of technology seems to create emotional states which are fraught with angst and frustration, instead of the more apt feelings of pride and confidence. For example, when planes take off today, usually somewhat late, we feel on edge, knowing that things could run on time if they were done right, and we feel annoyed that our thousand mile trip that will take about two hours, is going to take a half an hour more. And we wonder as we sit on the ground, in line waiting and watching others to take off, if our plane has had the routine maintenance, and whether it will function safely, and not crash. We, as Americans, expect technological solutions to work, and to work well, and we are not made happy, confident and cheerful when they do not. Americans are struggling with technological advances emotionally.

Americans still fear flying, bite their tongues in frustrations while sitting in front of computer screens, cruse under their breath if the computer doesn't seem to be doing what they want, when they want it to. They are exasperated when the telephone system seems overloaded, or when their microchip-laden car fails to start. This seems a curious phenomenon when comparing the American reaction to a foreigners. Phone systems in France routinely bog down. Water systems in Mexico hardly ever produce clean, clear, safe water. Refrigeration units in Lebanon are almost never able to produce cold, slow air, and the electricity is so uneven, televisions, elevators, lights, clocks, motors and frequently fail. So too does the notion of confidence.

While much of the rest of the world rejects our morals, our methods, our attitudes and sentiments, what it does want from us is our technology; our low, intermediate, appropriate, and most of all, our high technology. The Russians want it so badly they will steal it. They recognize its human value because they will allow their citizens, even their highly visible dissident citizens, to come to the United States for medical treatment, which translates directly to their respect for and awe of and inability to manufacture, produce, discover and use medical technology. They steal our computer technology for the power inherent in it speed, its computational quickness, particularly in fire and control system, and of course in the security of communications systems as well. They would like to produce it as the West does, and Gorbachev could be seen as the new Peter the Great, with an orientation to things western, which translates most readily to technological knowledge.

As I originally wrote this, I thought this made the point well. In a conversation with Robert C. Williams (personal communication, 1986), a Russian historian who has written about the espionage trial of Klaus Fuchs, I learned again that in Russia, everything is a state secret. The location of railroad stations is important and one cannot photograph anything that is a state secret, which means that one cannot photograph most of what exists in the Soviet Union. The depth of this differing mentality can be seen in the fact that Russian agents have routinely stolen Exxon road maps, the ones that were given away in gas stations, and sent them back to Moscow. But the point I want to make there is that you and I both know they are trying desperately to steal any and all technological secrets, and you and I cannot imagine the breadth of what this means they are trying to steal.

The Japanese and Germans perceive themselves to be locked in a dead heat with us, engaged in a competitive battle which will have high impact on international economics for the developed and lesser developed nations. Japaneses microelectronics are at the heart of the trade legislation before our Congress now. The entire electronics industry is in turmoil over just this issue. Lessor developed nations want from the United States any and every kind of technology that we or any other nation so inclined can provide. Water and sewage treatment electricity production, petrochemicals, pollution and pesticide controls, you merely have to name it and someone or some nation wants it. They want the entire spectrum from agricultural genetic engineering, to high tech glues.

It does not matter whether it is low or high tech, each and every kind is sought. Each has a perceived value, and each extracts a cost. For example, technology can be valued because it can reduce nutritional anxiety. It can and has increased dramatically the yield per acre, so that more food can be produced by fewer acres and fewer people. Yet there are indirect costs too, in that technology may now be responsible for our eating less healthy foods. These costs can take a variety of forms, some of which are not at all benign. For example, nuclear waste disposal, a topic that has placed North Carolina in the news recently is a problem created by technological solutions which is wrapped in human values discussions. Technology has created harmful by-products, and the storage of these by-products is emotionally embroiling, politically sensitive, economically costly, socially devisive.

I do not mean to suggest that there are not other kinds of technological solutions that are not just as internationally and culturally controversial. The Dutch government rejected petitions by vast numbers of citizens who did not want American Cruise missiles deployed in their countryside. Obviously the focus of the argument, one of the largest public debates in terms of percentages of individuals who became involved, was an unnatural object, the cruise missile, the product of American technologists. Now, only one year after these missiles have been violently debated and subsequently implanted, Secretary of State George Schultz and the Russian Foreign Minister Shevardnadze seem to have agreed to remove these missiles. It is no wonder that angst, frustration, confusion and loss of confidence are clear. Technology seems to be the heart and soul of foreign policy, among other aspects of modern life.

The first assumption here deals with the nature of our society, the nature of our nation and the nature and direction in which it is pointed, and it is pointed toward technological solutions, toward technological thought, or toward a technological mode of thinking. This direction leads to psychological states of uneasiness in many, to frustration, fear, anxiety, and despondency. This attitude which seems prevalent, and seems destined to become more prevalent given the direction of our society, has not always been.

Early technologies, such as garden tools, or stone bridges, or tractors may have implied that technology provided solutions, but the use of technological knowledge did not seem to create a sense of uneasiness, a sense of alienation, or a sense of frustration as many modern technological solutions do. Earlier technologies did not seem to create the frenzied moral, psychological, political, and economic dilemmas that many of our present technologies do. Early technological knowledge and its use seemed not to produce a sense of dread. This is an important point that I want to return to several times, because it is this point that suggests to us that we must act differently than we have in the past. This attitude of dread and rejection is concommitant with the advance of technological knowledge. When you are disheartened by something, you typically do not approach it, learn about it, play with it, think about it. Moreover, you typically do not attempt to become literate about it.

Technopeasantry

The second major assumption I want to make is that just as the peasants during the middle ages were unable to control their society, were bound to the land and bound to the masters of wealth, so too will be the problems of the technologically illiterate in our society. I want to assert that without technological understanding, or some form of technological knowledge one will be a peasant, a serf, a slave. Being a technopeasant, that is, being technologically illiterate, being technologically deaf and dumb, or being technologically incompetent is a very real and distinct possibility for many in our society. This second assumption deals with the question, "Who will be technopeasant? Are you one now? Are you about to become one? Will your students be technopeasants too? Will your husband or wife, friend or lover, mother or grandfather, secretary or boss, lawyer or doctor be a technopeasant?" Being a technopeasant implies being bound to the masters of technology, bound to the users of technological knowledge, subservient to its employers.

Moreover, being a technopeasant in any field can be dangerous. As an illustration I want to point out Molly Moore's article in the *Washington Post's National Weekly* edition dated October 27, 1986. In this article she points out that it takes 18 complex steps to fire a Stinger missile (a hand-held, shoulder-fired thirty-five pound, anti-aircraft rocket designed to shoot down low-flying aircraft), and this does not count the need for the soldier to hold his breath to avoid inhaling the noxious fumes it emits when it is fired." At $50,000 each, and weighing thirty-five pounds, the weapon is efficient, economic, but it is not elegant. Remember, it has been designed to cripple low-flying aircraft, essentially a one-on-one situation, with one infantryman against one or two air force personnel flying an aircraft worth 15-20 million dollars. "But when you have a weapon that an American high school graduate who's going to be in the Army cannot operate and maintain. . .that is a problem," says Lawrence J. Korb, the Pentagon's manpower chief from 1981 to 1985.

This second major assertion then deals with the fate of the faculty and students, particularly those who have not opted for a technologically driven, nor technologically sophisticated education. It deals with the citizens whose formal educational activity is over. It deals with individuals who attitudes and dispositions chart an educational course which steers clear of technological knowing. We have to ask this question in a serious tone. Will these persons suffer a loss of control? Will the person who has little or no access to technological knowledge during this or her grade school, middle school, high school, undergraduate or graduate education, by design and choice, suffer the consequences of peasanthood during the middle ages?.

The obvious answer to this question is "yes, emphatically, yes," and one can see that this has already happened and is happening in other sectors of the society. It has certainly happened and is true in business. You cannot run a business today without technology. It is true in medicine. You cannot go to the doctor's office, to a HMO, to a clinic or a hospital without first-hand experience of a variety of different forms of technology, nor can you be a competent health-care provider without an enormous shot of technology. It is true in publishing, where the revolution in desktop publishing is presently standing this profession on its proverbial ear. It is true in communications, with voice and digitalized data, and fax, and now private telephone-linked video. It is true in automobile manufacturing, and it probably true now in farming, where cattle performance, feed analysis, butterfat content and breeding are now monitored and evaluated technologically and that this is essential for the survival of the family farm.

This second major assertion contains within it the premise that students and citizens without some technological familiarity, some technologically linguistic skill, some technologically bound knowledge will become technopeasants. There are some obvious reasons why this will happen, and there are also measures that can be taken to insure that it does not.

Consequences of Technopeasantry

One predictable consequence of being a technopeasant is a lack of power. If knowledge is power in our society, then those with technological knowledge will hold the power. However, in our society, sharing knowledge has always been associated with sharing power. An informed citizenry is a distributed power base.

This distributed power base has always included persons educated in the Liberal Arts manner. If students of the liberal arts are vessels to be filled with the wine of knowledge, then the wines in these bottles are not and have not been technologically sophisticated wines. Either the wines have not been well-blended, or the conditions for vintage quality have been distorted. The wine-makers may also be in error. These individuals are persons who have chosen NOT to go to MIT or to Cal Tech or to Carnegie Mellon. This choice, this exercise of past learning patterns, of past knowledge which is familiar, shows us the wine of humanities, the wine of languages, the wine of history, classics, philosphy, psychology, sociology, anthropology, or economics. Thinkers ought not trivialize this choice, this orientation toward people and not toward things, an orientation toward interactive knowledge structures and not toward artifacts. Preferences, attitudes and sentiments, the stuff of great literature, and the guts of much psychological writings, are deep rooted and contribute more than their share of the weight to this problem.

Liberal Arts Colleges have produced more than their share of the leaders in our society, both in the public and private sector. Surveys of major corporations reveal that persons with liberal arts education comprise the vast bulk of CEO's and upper level managers, even in technologically driven companies like DEC or IBM or AT&T, compared to those who hold technical degrees. The same patterns hold for public office positions at the regional, state and federal levels. If we exhibit some form of thought pattern, some form of education or selection process has been responsible for this phenomenon, then we should continue to predict that liberally educated people will continue to want to be leaders. However, the character of society is changing rapidly, has begun to change more rapidly than ever before. The future leadership by the liberally educated person is seriously in doubt.

Doubts also arise when asking "Is a person truly liberally educated if there is no familiarity, no competence or literacy in technology." Are we remiss, derelict, negligent or worse, culpable for not having provided this kind of literacy. Again, the answer to this question seem relatively clear. "Yes, we are derelict and culpable if we don't provide such an opportunity. One question is "Why?" provide this kind of educational orientation and a subsequent question is "How?" to produce it.

First, I want to address the question of "Why?" Why produce, induce, provide or advocate such an education? To answer part of this question, one has to think about human interactions. One cannot enter into any debate, public or private, and persuade the other of the force or your argument if one does not know the facts, or one cannot know what others assume is known. Many of the debates, public as well as private, turn in large part upon issues technological. Those who don't speak the language of technology will not participate in the debate at an influential level. To think otherwise is merely wishful thinking. One other kind of an answer to the question "Why?" deals with the exercise of civic responsibility, and underlying that is the issue of power. Power in our democracy is uncheerfully given, to the leaders at any level of government. The power to control where nuclear wasste is going to be stored, or low level garbage is going to be dumped, or how a landfill is going to be created is never happily given over to another, and for substantive reasons. We usually settle these issues of power through debate and referendum, the power of the ballot box.

The second psychological and socially driven factor as a consequence of the direction that our society is marching in is that of alienation and resignation. If individuals become resigned to being technopeasants, feeling unable to know of their society and feeling that they cannot fathom what is occurring, they will withdraw, become isolationistic, ignore the whole and cease to participate.

But then, the question turns to "How?", how can this be accomplished? In what manner and what way can we adjust, if we care to avoid these radical and undesirable projections.

The New Liberal Arts Program, first conceptualized in 1981 by a program officer there named Stephen White. He proposed that the Sloan Foundation embark on a major program, which for them means 17 to 20 million dollars, over a five to seven year time frame. He wrote an occasional paper, published under the same name, in which various individuals were asked to respond to this idea. What I am about to elaborate is what the program constitutes today, and how much technological and quantitative reasoning it has spawned. Needless to say, it constitutes a programmatic response to what might have been called technological illiteracy, or a lack of substantive knowledge having a mathematical/quantitative base.

David Billington of Princeton University has spent a great deal of time trying to teach three unifying principles of engineering to liberal arts students. He thinks the unifying principles are elegance, economy and efficiency. By elegance, he means that the aesthetics of European bridge designers, and some American bridge and tower designers, seem to be unified with the sentiments and feelings of the society at large and with those who are experiencing the tower or Bridge. In his book, *The Tower and the Bridge* he draws comparisons between public civil works along these three lines. In separate volumes, he discusses the works of Robert Maillart and his analysis of the 1930 Salginatobel Bridge, in the Graubunden area of Switzerland, and *The Works of Christian Menn.* He calls attention to the aesthetics of the place and time. More than that, he calls attention to the parallels between the repair of public works and the well being of the society. When the society is running well, then the public works are maintained and cared for, but when society, free and open society, is derelict, then the public works seem to show it. When the roads and public sewers and public water systems fall out of repair, as has been the case in New York City, then Billington suggest to us that these values are the values reflected by the society, and can be seen as open and not closed. Nowhere has this difference been made more manifest recently that the accident at Chernobyl. The values that permeate the society also permeate the design and construction and execution of large scale public works, and that means the upkeep and preservation of those values and those public works. (explain)

There is another side to this issue, of what should be known, and who should know it?. Maud Chaplin, Dean of the Faculty at Wellesley, suggests that we should also look at the works of Martin Heidegger whom she insists argues

> "cogently and persuasively that the essence of technology is not technological. It is rather, a mentality, a way of looking at the world that is all-embracing and intrusive, seeking to control and domainate; by its insistence on order and rationality, this world outlook perceives nature as existing for the use of people. The ethic of mastery becomes the ubiquitous underlying value system which dictates all thought and action."

The question that Chaplin sets forth, and a suggestion implied by Heideggar is that the major problems engendered by technology are not technological but human problems--psychological, social, political, ethical. If this is so, then why do we need to understand the underlying technology? The mold of this question is not simple. It is a frequently asked question. It is a question that can take the form of "How much technology do I really have to know?" or as Patricia Johnson, Dean at Vassar puts it, "How much technology is enough?" and how will we know when we know enough? This is not a simple question and I want to give illustrations of why it is not.

The field I have been working in for the past four years is Bioengineering and Health Technologies. I have done this for a variety of reasons, some of which are quite personal. I want to speak about the economics of health care in the United States and I want to speak about the aesthetics and the metaphorical changes in the knowledge we have about our health care in order to give an indication of the inter-relatedness of technology, politics, economics and values.

Bioengineering & Health Technological Costs

First, in order to shock the sensibilities, I want to talk to your pocketbooks, our pocketbooks. We as taxpayers and buyers of insurance are the payers of the costs of medical care, and generally not the users. Health care is very expensive. The U.S. will spend more than $350,000,000,000.00 this year on health care. Either as a percentage of GNP or as a percentage of the federal dollars spent, health care expenditures are rising faster than any other sector, including military expenditures. Health care expenditures now account for more than 10.9% of Federal Dollar expenditures. One economist at MIT, Jeffrey Harris, facetiously, but only partly so, says that the only way he see to curbing expenses for military spending is by letting the cost of health care "eat up the extra dollars."

Some of these rising costs are due to an aging society, due to the number of workers who have reached retirement age. The number of newly retired is now growing at an alarming rate. Medicare and Medicaid, funders for many individuals, together with third-party payers, have instituted Direct Reimbursement Groups (DRG's) to contain costs and this has been some help. But the Claude Pepper's of the society are reaching into the pocketbooks and piggybanks of the young, and are going to drain the resources of any modern society at a precipitous rate. They are going to drain the savings and disposable incomes of children who have not yet begun to work, before they can vote, and before they can argue the basic unfairness. Health care is not now nor ever has been conceptualized as a *right*, yet the society, through the grapevine of growing technological and litigious costs, is barreling toward such a definition. Catastrophic health care recently proposed by the executive branch is merely one instantiation of this unfortunate idea.

Technological solutions for illness are patently expensive, and the pressure is on in every medically related sphere to have these enormous costs paid by the young and old healthy worker. Two dramatic examples can be found in the transplantation of kidneys, and now in the newer, most recently decided transplantation of hearts. Kidney transplants are paid for by public law, PL92-108 enacted in 1972, after only ten minutes debate in the Senate, no debate in the House. The program now cost more than 35 times the estimate given during that debate. The estimates of the legislators were precipitously in error and helped dramatically unbalance any budget. The kidney transplantation program is now the dominant "model" for the enabling legislation and debate on the transplantation of hearts. The programs are in fact technological miracles for those who receive the transplant, and medical miracles for those who perform the transplants, and at the very same time spell economic disaster and ruin for those of us who are left to pay the bills. These are exactly examples of technological competence without the debate, the articulate debate, couched in terms of the humanities, framed in terms of the egalitarian society, the debate that would not ever allow speech about rationing health care, or the wisdom of keeping a person alive on a kidney machine so that they can die of cancer. Technologies enable new ethical questions, questions which are not able to be asked unless the technology exists, and when the technology exists, there seems no easy way to grasp the issues. There seems to be no easy way to say, this is valueless, and it should not be funded with public dollars, or this is great, this is the stuff of life and vigor, and we should fund it at all costs.

Where and how is the student or the concerned citizen, or the informed leader going to hear these issues articulated if it is not by the academy, within the confines of a sphere of intellectual growth, of spirited intellectual debate? Technopeasantry is never being able to influence, in any perceivable manner, the central questions and answers to the above morass, and the loss of control seems obvious.

Now one may ask questions of the values of technological knowledge, and I want to confine my remarks only to the technologies of medicine. One can make remarks about the technologies of the other large portion of the federal budget, namely defense and offense in military technologies. I want to confine my remarks to medical technologies because for me, it iseasier to justify. The technologies are oriented toward the promotion of life, not its destruction by design. I recognize that statement to be arguable, however, not at this time.

Here are some give-aways. These images, the ones I am about to show you are some of the most important images ever produced in the history of mankind. Produced by Magnetic Resonance Imaging, they are kind in nature, for as far as we know, they do not harm the patient, unlike so many other medical procedures, including most other ways of producing images from inside the body, such as X-rays, or sonograms. These images, like Billington's images of bridges and towers, are of public/private works. By that, I mean many of the first images were produced by machines funded by public dollars. They now are being bought by any reasonable hospital, and are privately produced, even though some of the very best research and development takes place in major research universities, such as the Francis Bitter National Magnet Laboratory.

Why are they some of the most important images. They give high resolution of soft tissue with incredibly clear definition inside some of the most difficult places to look without damaging the patient. They give clear images of the posterior and media fossa, an area of the head which is thick with bone. X-rays, which depend on material density differences to produce images are absorbed by bone more than bone more than they are by soft tissues. When X-rays pass through material and are absorbed at differing rates according to density, and bone being denser than brain, it is a difficult thing to get a picture of a brain, encased in skull. Magnetic Resonance Imaging on the other hand, depends on an entirely different principle, namely magnetic fields and radio frequency pulse sequences. MRI is non-ionizing radiation, cannot harm genetic material the way X-rays can. This is no small achievement. CAT scans of the brain usually use some radio-isotope, or tracer as a contrast agent, and alhtough touted as benign, certainly increase the risk to the patient.

The questions I have mentioned entail some simple observations as well. Technopeasantry means a loss of status, a loss of leadership, a loss of decisiveness, a loss of self-control, a loss of stewardship, and a loss of self-esteem.

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Technological Literacy - One of the New Basics

Study on the Justification of Technology Education as General Education

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Introduction

It can be said that modern society depends upon technology. The term "industrial-technological society" expresses the meaning of this statement. In this sense, this paper shall examine the characteristics of modern society related to technology and inquire into the justification of technology education.

Also, a justification of technology education based on the nature of human development will be presented. Since the beginning of history, human beings have made and used tools. That is, we assume that manipulative ability is our nature.

In this paper, I will discuss the justification of technology education on above two points of view.

Modern Society and the Justification of Technology Education

Technology is the most basic common culture in modern society. Nobody will have any objections to this statement. However, in an historical context, it could not be accepted as a fact until the emergence of modern industrial society. Technology in the early and middle ages was mainly a means to earn a living for lower class people including slaves. For instance, in early Greek culture, the Banausic Craftsmen were held in the class just above a slave (Hoster, p. 212). That is, technology and hand work were acknowledged as lower class culture and upper class people were so far from it.

Even in the Medieval period, technology belonged to the lower working class as their means to earn a living. Hence, apprenticeship in the crafts were a primary means of education available to the youths of working class (Martin & Luetkemyer, p. 20). In other words, technology was not general and common culture that was taught to everybody. In a traditional agrarian society, technology again was needed only by the lower class people as a means of living.

However, technology in modern society is an essential component to everybody's daily life. Since the Industrial Revolution, technology was developed more rapidly than any other time in history and consequently has made great contributions to industrial and economic development. Owing to these development, we can now enjoy convenient modern living. Of course, the development of technology produced reverse effects, too. As an inventor or user of technology, we have to experience both sides. Through our occupations, we either produce technological products or use them. In other words, regardless of our socio-economic class, we are closely associated with technology. In this sense, technology can be defined as basic common culture in modern society. Therefore, if general education is to educate general and common culture, technology education has to be a part of general education since it is defined as general and common culture.

Reducing the characteristics of modern society in one word yields industrialization, which means industrialized society. If industry is a economic activity in which we change the forms of materials to increase their values for human wants and needs (Towers, Lux, & Ray, 1966, p. 40), industrialized society is a society that is based on industries. As we experienced through Industrial Revolution, industrialization was possible by technological development and technological development was accelerated by industrialization. What happened was that in order to have better competition, we needed to have new technology and thus invested lots of time and money to develop technology. Accordingly, we can produce almost everything in industry; that is, production and economic activity are totally dependent on industries. If modern society depends on industry and industry depends on the development of technology, then what is it to understand modern society?

to make a long story short, to understand modern society means to understand technological civilization. If this undersanding is not achieved, we miss a very important part of our modern society. Every student learns about natural science, but that does not mean that all students become natural scientists. It is because they need to understand natural science to live effectively. For the same reason, students also learn social science. In other words, it is very important for us to understand both sciences as a ground of life.

Technology has rather short history of being taught in school. That is because technology was not taken seriously until Industrial Revolution. Of course, our life had some relation to technology even before Industrial Revolution, but it was very simple and traditional practice. So, it did not have to be taught in school.

However, since technological civilization became the ground of our society, we have to understand technological system in order to understand our society itself. Now, technology is not just for lower class people but for everybody.

We have used the word "participatory democracy." Now, we have a new word "participatory technology" (DeVore, pp. 333-338). This word shows one of the characteristics that citizens living in high technological society must be equipped with. In a democratic society, it is most desirable if everybody can participate in social, economical affairs and exercise his or her rights and duties. But in order to do that, it requires him or her to have sufficient knowledge about social and political process. In this sense, participatory democracy requires its citizens to have more abilities and responsibilities for learning.

In high technology society, democracy means more than political participation. Citizens need to have a good stock of knowledge about technology. Nowdays, our daily life is related to technology in every sense. Without knowing what it is, we face difficulties even in personal life. Hence, to make everybody acquainted with technology became a major task of participatory democracy, and technology had to be a required course in every level of schooling.

By the previous discussion, it is possible to conclude that technology means general knowledge necessary for participating in social affairs as citizens of democratic industrial society. Participatory technology requires every citizen to possess technological literacy with responsibility. Moreover, it should not be just a skill useful to daily life, but understanding about technological system rooted in the society. Therefore, technology education should be accepted as general education to understand technological system as our living environment.

Human Developmental Needs and the Justification of Technology Education

Since the beginning of history, human beings have made and used tools. Human history is indeed the history of the development of tools. Many philosophers said that human ability and desire to make something is one of human nature. For example, Henri Bergson, the French philosopher pointed out that there are two aspects of human nature in the philosophical and historical context: homo sapiens and homo faber (Goudlge, pp. 290-291). He described homo sapiens in connection with rationality and homo faber in connection with tool making ability. Psychology Jean Piaget also classified human intelligence into two categories through his study; rational intelligence and practical intelligence (pp. 119-155). He suggested that rational intelligence is an ability to understand abstractions and practical intelligence is an ability to operate physical objects. Jerom S. Bruner proposed "a course of study on man" through interdisciplinary approach including sociology, anthropology, psychology, etc. in order to make students understand human nature. In this course, he divided human characteristics in five categories and put tool making ability as one of them (pp. 73-101). Gilbert Ryle who was a psychologist and philosopher also divided human knowledge into two categories: "knowing-that" and "knowing-how."

Homo faber which Bergson pointed out in relation to tool making ability can be conceived as technological human nature. The practical intelligence described by Piaget can be regarded as psychological nature of technology in the sense that it is an operational ability to handle physical objects. The distinction by Ryle can be considered as an explanation on epistemological nature of technology.

Judging from the above discussion, if there is a human nature whatever it might be, technology should have some relation to it.

According to the taxonomy of educational objectives by Bloom (1956), human ability is divided into cognitive, affective and psychomotor domain. Human nature that Bergson, Piaget and Ryle talked about has something to do with this psychomotor domain directly or indirectly.

If we human beings are born with some abilities related to technology, it is natural for us to desire to develop them. That is wahy we need technology education and coordination of its subordinate factors. Fleishman pointed out that there are two aspects of psychomotor ability. One is about the area of physical proficiency such as strength, flexibility, speed, balance, coordination and endurance. The other is about manipulative skill which is related to manual dexterity (pp. 245-286). This tells us not only the necessity of technology education, but also the content of it in the sense that it talks about developmental needs of human beings.

According to Piaget, intelligence is an adaptive process learned through active transaction with a person and his environment, and children can learn through the use of manipulative materials and direct experience (Elkind, , 1974). Piaget also implies that children can learn more actively through actions rather than teacher's explanation or reading a book. In order to have active learning experience, children manipulate and coordinate various materials. Thus, if we think of these actions as technology itself, technology education is deeply related to the basic developmental needs of human beings.

According to the results of the psychological studies including Piaget's theory, children evolve a stable body of useful information concerning their environment through the development of a number of motor patterns such as locomotion, manipulation, balance, throwing and catching. According to Piaget, the initial information about these motor patterns is motor knowledge. And this motor knowledge system can be developed by interacting with the objects in their environment. The development of motor skill including sensory motor skill, perceptional motor skill and psychomotor skill is then basically connected with technology education. Especially at the primary school level, technology education should be consistent with such developmental needs.

The manipulation and coordination of objects and materials require more than physical function. It is possible when we can practice our judgement in accordance with our physical function. In this sense, the concept of technology focuses on psychomotor skill. Technology education, of course, should be related to manipulative function and serves its develomental needs, but the meaning of technology is now extending to include not only manipulative function, but also technological literacy.

The emphasis on technological literacy in technology education means that there are needs for technological knowledge. Technological ideas and understanding are new developmental needs raised with the development of technological civilization. According to the studies done about technology education, most students and citizens have needs for is technological knowledge. That is to say, even if technology is human nature related to developmental needs, content of needs can be different by the changes of time and environment. Hence, technology education should recognize developmental needs of human beings continuously and develop the contents accordingly.

Concluding Remarks

So far, the justification and necessity of technology education have been discussed on the basis of the characteristics of modern society and human nature. It is emphasized that technology education should be a compulsory course for all students at all levels of school education in order to understand modern society, which depends on technological civilization as one of our environmental factors. Moreover, technology education has been recognized as an absolute part of general education for developmental needs related to manipulative function.

Technology education can be always justified in terms of general culture and developmental human need as discussed in this paper. However, the specific contents of technology education should be varied in accordance with time and environment in which people are living.

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A Case for Technological Literacy

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In the past few years there have been many studies of education in the United States. One of the most prominent and most quoted is "A Nation at Risk." The opening paragraph states, "Our nation is at risk. Our once unchallenged preeminence in commerce, industry, science and technological innovation is being overtaken by competitors throughout the world." Thus it is noted that the nation is at risk not because of a dearth of literature and the arts but because of a slowdown of development in science and technology.

As an example of this, recent reports indicate an ever increasing portion of worldwide commercial airliner orders going to manufacturers in England, France and Italy. This has been an almost unchallenged American domain for the past forty years. We are all too aware of the challenge to domestic production of automobiles, steel, shoes, clothing and electronic assemblies from foreign competitors.

The "Risk" report further states that educational deficiencies come at a time when the demand for highly skilled workers new new fields is accelerating rapidly. For example:

- Computers and computer-controlled equipment are penetrating ever aspect of our lives--homes, factories, and offices.
- One estimate indicates that by the turn of the century millions of jobs will involve laser technology and robotics.
- Technology is rapidly transforming a host of other occupations. They include health care, medical science, energy production, food processing, construction, and the building, repair, and maintenance of sophisticated scientific, educational, military, and industrial equipment.

. . .within the context of the modern scientific revolution, we are raising a generation of Americans that is scientifically and technologically illiterate.

(There is a) growing chasm between a small scientific and technological elite and a citizenry ill-informed, indeed uninformed, on issues with a science component.

The nation had received previous warning of this impending problem in many studies and reports of education in the past two decades. As an example, a book entitled, *Man, Education, and Work* by Grant Venn in 1964 cautions,

> Unless far more and far better education on the semi-professional, technical, and skilled levels is soon made available to greater numbers of citizens, the national economy and social structure will suffer irreparable damage.

Former U.S. Commissioner of Education, Ernest L. Boyer, assisted with a report similar to the "Risk" report. Also conducted in 1983, it was sponsored by the Carnegie Foundation and was entitled, *High School, A Report on Secondary Education in Amercia.* Referring to that report, Mr. Boyer later stated:

> In the Carnegie report we also call for a study of technology for all students. I do not believe that we can within the four walls of every school and within the four years of high school prepare students for every specialized occupation.
>
> But we can and must help every student learn about the technology revolution, which will dramatically shape the lives of all of them.

Arguments over definitions of technology are numerous. Most of the definers belong to a few percent of our society who are themselves technologists. To the average person, technology is a mystical black box. With wheels on it, it can be driven to work or to the supermarket. With hinges and some insulation, it becomes the door to a refrigerator or microwave oven. With a bit of rounding of the corners, a nose cone up front, and a rocket motor in the back, it threatens nuclear winter.

Many nations of the world are classed as underdeveloped countries. This classification is not because of a deprivation of literature, the arts, laws, social customs or great leaders. These nations have their own art forms, legends, folk heros, customs, mores, and taboos; many of which rival the best of the "first world" countries in philosophy, depth of meaning, and social development. The label "underdeveloped" stems, rather, from a deprivation of technology and an increased standard of living comparable to the more advanced nations.

In the TV series "Connections" (which I heartily recommend for your viewing) featuring the history and development of technology and the chain reaction of technological events and their effect on society, the commentator, James Burke, suggests that the development of the moldboard plow was the single most significant element in allowing society to progress from a subsistance agrarian economy to one where there was a surplus of food where some people could begin to devote their time and talents to other endeavors. "Civilization" thus came into being. It is significant that many of the least developed countries have not progressed to the moldboard plow--they still subsist with the digging stick or the stick pulled by a draft animal or a fellow human being.

We have barely comprehended the influence of technology on natural and societal systems of the past. The understanding of its future impact is even more remote. But as the gifts of technology become more pervasive and its concomitant problems more critical, there is a compelling need for as broad an understanding as possible. The technologists must give more thought to the uses of technology and their impact on nature and society. The nontechnologists must no longer regard technology as something that works magic for or against them.

It is interesting to contemplate the influence of technology upon our modern lives. The question may be asked, "Can you think of any aspect of your daily living which is not influenced by technology?" The difficulty in determining an answer to this query illustrates the influence of technology. This influence is expected to increase. Consider the development of technology during the lifetime of older persons now living--from the fastest form of transportation being muscle power (the speed of a horse) to speeds in excess of 100,000 miles per hour in space ship travel. A supercomputer at Los Alamos National Laboratory is said to be able, at the rate of 780 million calculations per second, to perform more arithmetic calculations within one day than did all of mankind previous to 1970.

Broadly speaking, the study of the implications of technology upon society could become an integrating factor for all of education. It has been previously noted that students in the secondary school system must become technologically literate. James R. Johnson, laboratory director of the 3M Company has emphasized the holistic integration of technology education,

> Much has been said of technological literacy, usually meaning that nontechnologists must learn some technics. But this is not enough. Modern technology and its implications require a holistic, integrated understanding that permeates all segments of our society. This is for education a goal whose time has come.
>
> In its modern garb, technology may be too new on the human scene to be fully understood. Nonetheless it is the responsibility of education to acquaint all members of our society with some measure of its technics, including hands-on practice. And of equal importance, education must deal with the social and political consequences of technology, both as history and future. Technology education in this holistic sense has an unprecedented challenge!

Walter Waetjen, President of Cleveland State University, has likewise sounded the call for a broad study of technology at all levels of education.

> Technology education in the United States has, for all practical purposes, been focused strongly on the technical side. In the elementary and secondary school, we entrust technology education to the mislabeled "shop teacher." At the university level, technology is placed in the hands of the engineers, ceramists, or print makers. More recently, technology has been equated with computer centers.
>
> No matter the level of education, we do not seem very concerned with technology being part of the humanities, the arts, or the policy sciences. . .We cannot continue to limit the study of technology to its technical aspects alone.

Universities and secondary schools can use

> technology as one of the integrators or themes that would run through the entire curriculum. Were this to be done, students might develop a better understanding of the impact of technology on social change.

Traditional liberal arts colleges have also begun to realize the importance of including the study of technology in their curriculum. According to A. Emerson Weins, a professor at Nethel College, Kansas,

> While secondary education is currently being challenged to return to the "basics," liberal arts colleges are being challenged to broaden and update the liberal arts curriculum by including a study of technology in the general education program. The impetus for a new look at the liberal arts comes in part from within, but it is also being prompted by business-backed foundations who recognize the need for more informed decision makers. W. Dale Compton, Vice-President for Research at Ford Motor Company, states, 'The impact of technology is so great, and the questions posed are so important that responsibility for weighing the repurcussions of technology cannot be relegated solely to the technical specialists'.

People lose their price and their self-esteem if they are not involved in quality productive activity. Part of the cause of the current drug epidemic may be that people lack a sense of direction and personal value and esteem. It is difficult to perceive their worth and to establish a personal niche in a technological society. Again, Ernest L. Boyer has said,

> The fifth priority of excellence, (in education) which I happen to believe in passionately, is acknowledging the dignity of work. The truth is that work is at the very heart of our existence. It's through work that we define who we are. And it's through work that we give special meaning to our lives.
>
> Education is not simply something that we engage in as an end in itself. We develop our talents, our skills, and our ideas in order to be productive, to make something useful of our lives. That's what I mean by work.
>
> . . .The time has come to acknowledge that a study of work is a part of the core curriculum of every student.
>
> What I find scandalous today are the mindless distinctions drawn between so-called academic and non-academic programs. I find it equally scandalous that some jobs are generously approved while others are cynically condemned.

In a similar vein, John W. Gardner, former U.S. Secretary of Health, Education, and Welfare, said,

> . .the society which scorns excellence in plumbing because plumbing is a humble activity and tolerates shoddiness in philosophy because philosophy is an exalted activity, will have neither good plumbing nor good philosophy, neither their pipes nor their theories will hold water.

While the recognition of the importance of technology and technology education by at least a few others in educational circles is comforting, that comfort is short-lived when we realize the challenge which faces us as technology educators.

It has been estimated that the total technological base doubles every five years and some authorities say that the doubling is presently in as little as three years. The students currently in kindergarten will be graduating from high school and entering the work force or pursuing other educational endeavors in about the year 2000. At the present pace then, by 1990 or shortly thereafter, the technological base will be doubled, by 1995 it may double again, and again by the year 2000--or eight times the current technological base! Can we even attempt to imagine the technological challenges which will face the students now in kindergarten! However, the inability to imagine such marvels does not lessen the requirement that they be prepared in the best way possible. They must become technologically literate in the school systems to cope with the opportunities of the future. Our challenge as faculty is to stimulate a love of learning and broaden the vision of potential and provide relevant activities so that our students will not only be able to cope with advances in technology but indeed be on the leading edge in the development of those technologies.

In Utah, we sing the songs of Zion authored by inspired pioneer forebearers. We shed a tear as we read of their struggles in settling the western wilderness. But among the things we most appreciate and marvel at are their applications of technology to monumental developments achieved with limited resources--the magnificance of the temples, the marvel of the construction of the Tabernacle, the ingenuity of materials procurement and handling, and the foresight of design which would incorporate later technological developments. We are all aware of the magnificance of Rome and of Athens and of the pyramids and temples of Egypt. We know of the cities and temples built thousands of years ago in Central and South America. We are aware of them basically because of the remains of their technology. We know of the Michaelangelos, the DaVincis, and the Galileos of a few hundred years ago. These civilizations or individuals had technological understanding which was far ahead of their time. Dare we deprive our students of a similar foresight to prepare them for the time in which they must be the pioneers?

A few months ago I attended a CAD/CAM workshop sponsored by the State Department of Education at a rural high school in Utah. At that workshop was a teacher who had graduated just a couple of years before I did and has been teaching at the same high school in Salt Lake City for the past twenty years or so. I have not seen him at many of the professional meetings which I have attended, so I made a point of chatting with him. After seeing some of the miseries that we go through in trying to understand and implement the new technologies, he commented to me, "This stuff is too confusing for me to learn so I'm just going to ignore it. I've only got twelve more years until retirement anyway." How selfish and shortsighted! He is the teacher! The leader! He has already deprived at least a half dozen year's worth of students from participating in the kinds of activities that will increase their technological base, make them more appreciative of the position of technology in our present society and prepare them for jobs in the workplace of today and tomorrow. Can we, or they, afford another twelve years of similar instruction? Programs such as this will not be killed by the trend toward more academic graduation requirements or the "return to the basics" movement. They will die of themselves, from a lack of care and nurture and vitality from the professional who has been entrusted to lead his students to new heights of understanding in contemporary practice. All too many students in traditional industrial arts classes suffer a similar deprivation. They are very little better off than students in "third world" schools.

Over the years there have been many surveys conducted and committees established to determine the major goals of education. Some of the goals developed in these studies relate to "learning how to learn," and "learning how to adapt to change." If those are some of the major goals of education, we in the profession must certainly reflect those goals. We must learn new concepts, incorporate new technologies, and change those portions of our programs which are not up to date. We have done some grand things over the years and need not discard them all. But neither can we be deluded that past successes will guarantee interest and intrigue in our current classes nor insulate our programs from serious scutiny in the strains of the budget crunch. In many cases, we need only to change the emphasis and incorporate a little less pure skill development and stress more of the ideas of the effects of a certain product or process upon nature and society. We need also to infuse new processes and machines into our curriculum wherever appropriate. We excuse ourselves by saying that no funds are available--and funding is certainly scarce. But most of the machines which can be utilized to give instructional experiences in new concepts are much less expensive than the traditional woodwork and metalwork equipment which we buy or replace each year.

Students must learn that while they have the opportunity of being tutored by masters of learning--men and women who have shown by their own example an acquisition of knowledge and an adaptability to change, they also have a significant individual responsibility to promote their own growth and attainment through personal drive and initiative. Students, through the example and precept of dedicated learning on the part of faculty, will come to realize that learning is a lifelong process and that indeed as the ceremony states, graduation is but a *commencement* of education and learning. We must all understand the reality of the statement, "the bigger the island of knowledge, the longer the shoreline of wonder."

Schools must shoulder the responsibility of preparing students who can go forth to serve, who appreciate the opporutnity to stand upon the shoulders of those who have gone before to prepare the way, who are loyal to the grandest ideals of all generations, who are teachers and practitioners of technology who can help to push forward the frontiers of learning and can also assist our countrymen and people in underdeveloped countries to increase their standard of living and help them envision themselves as noble children of a loving God, not kinsfolk to brute animals of prey and toil.

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Technology: The Newest Liberal Art

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Efforts to define and clarify the goals and methods of formal education are clearly evident throughout history. The early work of Pestalozzi emphasized the common goals of the teacher and student as discovering the laws which govern humanity and nature. Herbart emphasized the psychological approach to understanding the needs of the learner. Froebel believed that children should cultivate their sense of self-identity in play and similar activities so as to develop a child's perception of the world.

These educational goals, centered on the early development of the child, are sound and few could argue their validity. While consensus among the ideals is likely, the method for achieving these ideals remains as diverse as are the individuals who profess them.

In a similar sense, as we search for a definite goal statement for a liberal undergraduate education, a variety of valid statements can be found. A mission statement for a liberal arts college, cited in Boyer (1987) is one such example. It reads:

> The college stands for an education that will give each student the skills of communication, the ideas and principles underlying the major areas of modern knowledge, the understanding that learning is a continuous lifetime process, and the courage and enthusiasm of a better world. (p. 60)

Once again, these objectives are not difficult to identify with, however, a great disparity is likely when methods of attainment are suggested.

As curricular modification is in progress for many undergraduate institutions, equally agreeable goals are visible as objectives-in-common, but the details of how their implementation will occur are not so clear.

Specifically, many undergraduate institutions are in the process of rethinking and redesigning their core curriculum. General ideas are, as a rule, agreeable and very desirable. The quest for a common core is an important and perplexing issue. Boyer (1987) asks:

> Can the American college, with its fragmentation and competing special interests, define shared academic goals? Is it possible to offer students, with their separate roots, a program of General Education that helps them see connections and broadens their perspective? (p. 83)

It is not uncommon to find faculty and departments competing for access to General Education course offerings. In an age of diminishing student pools and increased competition for students, the general education program is a means of access to potential majors.

This misuse of the core curriculum is a result of the political structure of the college. When the budget and faculty size are based on the number of majors, its simply a matter of survival. The problem is a systems problem. In complex situations it is necessary that conditions which impede progress toward valued goals be eliminated. A faculty cannot be expected to be free to explore untraditional options for the common core, while at the same time be plagued with possible dismissal. This cannot possibly result in a truly natural and unbiased program development.

In a similar sense, if the institution in any way expects to tap all options for common learning, at no time, should a simple dividing of the academic pie be considered. Dewey (1938) warned:

> It is the business of an intelligent theory of education to ascertain the causes for the conflicts that exist and then, instead of taking one side or the other, to indicate a plan of operations proceeding from a level deeper and more inclusive than is represented by the practices and ideas of the contending parties.

> This formulation of the business of the philosophy of education does not mean that the latter should attempt to bring about compromise between opposed schools of thought, to find a via media, nor yet make an eclectic combination of points picked out hither and yon from all schools. It means the necessity of the introduction of a new order of conceptions leading to new modes of practice. (p. 5)

Following Dewey's line of reasoning, the task is not to design a core curriculum based upon who yells the loudest or the longest, or to use compromise as a rationale for curricular design. The basis of an appropriate rationale is centered on the student; how students learn, what is necessary for a cohesive educational experience, and how can students be best prepared for a future, which is at this time, unknown. Boyer (1987) writes:

> General education is not complete until the subject matter of one discipline is made to touch another. Bridges between disciplines must be built, and the core program must be seen ultimately as relating the curriculum consequently to life. (p 91)

Boyer further states:

> This nation and the world need well informed, inquisitive, open minded young people who are both productive and reflective, seeking answers to life's most important questions. Above all, we need educated men and women who not only pursue their own personal interests but are also prepared to fulfill their social and civic obligations. And it is during the undergraduate experience, perhaps more than at any other time, that these essential qualities of mind and character are refined. (p. 7)

These stated ideals suggest a common core that is considerably different than what is known as traditional liberal arts. It is not that traditional subjects have no place in contemporary education, but possibly the methodology is inappropriate. From a student perspective, the market is changing. Students are more likely to pursue what they want in educational experiences, or what they feel has value or meaning. There is a general unwillingness to take classes simply because they are required. Obvious value must be apparent. Some suggest that today's student is too materialistic and tends to choose classes which specifically relate to economic gain after graduation. Krubowski (1985) writes:

> What do students want? For what they and their parents willing to pay? In a word, the answer is status, especially the status that is attached to a pretigious institution. Students are eager, and more willing to pay, to attend a college with the reputation or programs they believe will lead to high paying jobs and top professional schools. The market for entry papers to propserous middle class life is booming: the market for an education, especially the traditional liberal arts education that's been so central to our collegiate tradition, is dying. (p. 21)

This description of today's college student may be an over simplification of reality, but inherent in this trend is great potential for exciting course options. What should be obvious to curriculum designers is that our world is changing. The problems in environment, social strife, economics, human health, and technology in general are undergoing rapid changes as well. The interconnectedness of disciplines is more apparent than ever before, and the effects of today's decisions are long lasting and in many cases, irreversible. This reality sets the stage for many new educational designs which incorporate real-life problems in a real-life context. The decision making process of today is plagued with consequences. Today's college graduates must be prepared for change and the effects of change.

The Ohio State University's Special Committee for Undergraduate Curriculum Review is currently studying issues very similar to ours. Their clarity of purpose is stated in the following text. They report:

> Although our goals remain the same, the nature of the modern world may demand a sweeping revision of means to achieve our desired ends. The educated person, many authorities suggest, must be prepared for lifelong learning. The rapidity and magnitude of technological and social change will continue to transform our world. Established jobs and occupations will disappear and new ones will appear. Institutions will be radically altered, presenting new and perplexing problems. Educated people, to deal with these changes, will need to develop a much higher level of intellectual flexibility and social intelligence. If this higher level is to be achieved, our students must be informed by the past, knowledgeable about the present, and intellectually prepared to meet an uncertain future. (p. 1)

This "higher level of intellectual flexibility and social intelligence," to have meaning, must be addressed in a real-world context; the content of futures in science and technology. The future in science, as Kranzberg (1968) suggests, affords limitless possibilities and futures in technology pose cautious advancement in light of social, ethical, and environmental restraints. Together, these two disciplines provide a rich inventory of contemporary issues to support study in lifelong learning.

This beginning for lifelong learning must promote integrative thinking which requires leaving disciplinary vacuums. "No real-world problems can be fitted into the jurisdiction of any single academic department" (Cleveland, 1985). Cleveland also suggests that the vast potential in information sources makes it possible to access enormous quantities of data. He writes:

> Tools such as these empower those who learn to use them, to make complex judgments in the mindful knowledge of alternative futures. Systems thinking has created new ways to help encompass in a single mind some approximation of 'the situation as a whole' as it relates to the problem being studied. (p. 20)

The information at hand should only be considered a tool and not an end in itself. Educators must use these available resources in the process of developing a more dynamic curriculum. The vast reservoirs of data, however, should not attempt to limit the curricular design to purely scientific or technological ends. The new curricular models must acknowledge the human element as part of the integration of scientific and technological imperatives. According to Cleveland (1985):

> Honing the mind and nourishing the soul are both functional in the new knowledge environment. What we need now is a theory of general education that is clearly relevant to life and work in a context of the information age--a rapidly changing scene in which uncertainty is the main planning factor. (p. 20)

As new curricular innovations begin to evolve, the method and process of education are likely to change significantly. As the knowledge mass increases at an ever staggering rate, it will be increasingly difficult for faculty to keep up with the new information. The real-world context poses a threat to traditional education. The new education will likely see teachers as resource persons guiding students to information sources, through research methodologies, and to improve communication skills.

The real-world context requires that the college graduate be prepared for an ever-changing future, be able to see relationships between disciplines, and be open to change as well as being vital in the change process.

A new binding element is necessary in the format of the common core. Technology and the technological choices of today and tomorrow will have the greatest future impact on the world's people. Most every issue in our society has technological implications. One must be able to see implications and ramifications of impending technological decisions.

A well educated citizenry will have the decision making power for tomorrow. "Technology is preeminently a social process, and is not to be thought of as something affecting humanity from without" (Pfnister, 1985). Herein lies the tie-in with Kranzberg's earlier idea that futures in technology pose cautions advancement in light of social, ethical, and environmental restraints. Technology does not rule the populace, the educated populace rules the technology and determines the appropriateness of technological innovation.

If college curriculum committees are at odds over the apparent lack of student interest in philosophy, history, ethics, foreign language, communication skills, and the natural and social sciences, the real-world context of technological endeavors provides an arena in which these issues may be actively debated, alternatives posed, and solutions presented. If general education is in need of relevancy, one must only look to the events of today to find subject matter.

To enact a vital core curriculum whose components include technology, four imperatives must be woven into the fabric of the core.

First, learning must be treated as an ongoing activity. The new and vital discoveries in science provide more options for technology and humanity. Our vision of the future cannot be limited simply by what we know today. An understanding of technical means provides the information for building new relationships in other technological situations. The insight or vision of one innovator can easily be built upon by another. This brainstorming effect is an ongoing process which can provide for solutions when the students involved are open to new knowledge. Beyond the undergraduate experience, the work place demands as much and more updating to compete in a changing society. Beyond a career implication, family life, local and regional referendums, home investments, and investments in routine commodities requires discriminatory knowledge.

In addition to a commitment to ongoing learning a passage from connections to perspectives is necessary. So often concepts and systems are taught in an analogous format. Mental connections can readily be made following the understanding of like applications.

Cross-disciplinary connections are more difficult to incorporate in the classroom because teachers of single disciplines find it threatening to venture into unfamiliar areas. This is understandable, but since the objectives are to show connections, a rationale for bringing disciplines together must be developed.

Studies in technological and cultural evolution can provide many case studies of how inventors think, or how cultural changes were made possible by technological innovation. One need only consider the changes in our society since the advent of the silicon chip to get a feeling for the connections. Looking back in history one can easily trace the developments as they occurred. The interrelatedness of the puzzle pieces is evidence of the validity of an interdisciplinary approach.

Students seldom think in an interdisciplinary fashion. Few teachers use this method of addressing their course content. A connections orientation serves as a basis for a new teaching method. Through this case study exploration, students can better see how interrelationships exist.

After this exposure to interwoven relationships in selected situations, the students can now begin to explore the concept of perspectives. This adaptation requires a quantum leap in mental processing. Knowing how the pieces in the puzzle fit in past situations, students must now be able to think in terms of futures, projections, and forecasting. The greatest challenge is accounting for all the variables. When all the elements are assembled, predictions of trends, environmental effects, and social consequences can be made.

Thirdly, an integrative rather than interdisciplinary curriculum design must be developed. Interdisciplinary studies imply a mixing of diverse subject matter areas. Integration suggests as interwoven network which allows each to work to complement the other. Boyer (1987) writes:

> As students see how the content of one course relates to that of others, they begin to make connections, and in doing so gain not only a more integrated view of knowledge but also a more authentic view of life. (p. 92)

Integration of disciplines is present in natural sense when real-life situations are used in the classroom. A teacher does not have to fabricate circumstances to promote integration of subject matter. One needs only to observe society. The difficulty is to unfold given circumstances so as to see how all of the components work together. This is a task for students with faculty help. These are the parallels to life's circumstances. As part/whole relationships unfold, the concept of integration can then be applied, with confidence, to perspective or futures. Students can begin to build models of probable outcomes using a variety of choices in science and technology.

Finally, the design of curriculum which attempts to explore technoogy, past, present, and future, must do so by placing the responsibility for information gathering in the hands of the student. The traditional structure of teacher disseminating knowledge to students will not work here. The rapidly growing volume of knowledge in the field of technology as well as all of the integrated input of other disciplines, makes it impossible for any individual to be a complete store house of all facts. As mentioned earlier, the teacher's role must now be one of resource person. Technology has given us the information age, now it must be used to the best advantage.

Students must be taught the variety of options available for information gathering. Procedural methods must be reaffirmed so that students know who to progress in a self-directed format. Scientific verification must also be used. These processes can then be applied to any problems, in school and beyond. Given a complex problem today, few students know how to arrive at a solution.

The four imperatives identified here are essential for a vital common core. New courses designed to rearrange subject matter in different ways without considering an ongoing commitment to learning, integrated designs, passages from connections to perspectives, and the value of information handling, fall short of mirroring real-life situations. These implications set in a real-world context with technology as a common binding element can bring about a new form of liberal learning.

Within the bounds of society exists a wealth of challenges which threatens the human condition and environmental stability. There are also a wealth of opportunities to improve on these concerns if comprehensive and creative thinking are employed. Technology often gets blamed for societal problems and likewise is looked to for answers. The human element is the greatest threat to the human condition, and at the same time, the greatest asset. The missing ingredient is effective education. The new core curriculum which embraces technology in a global context can alter this deficiency.

The imperatives identified suggest a specific approach to the study of technology and technological literacy. Efforts in technology education at the secondary level employ a historical approach in some cases. These efforts are very appropriate when applied to children. They demonstrate how inventors think and assemble ideas to develop new technologies. The new program applies science and mathematics in an attempt to develop a better understanding of the underlying principles in modern technology.

Programs of this nature are valuable for young minds attempting to see relationships in our world. The undergraduate common core must rise to a higher level of involvement and understanding. Casual effects on a regional, national, and global scale must be addressed. Economics, environment, human health, ethics, and social well being must all find a place in this curricula approach. A technologically literate person must not only know how things work but must understand the effects of technologies on humanity and the environment. Comparative analysis of options must be used to seek out the most appropriate technological means. This is technological literacy at the undergraduate level. This must be a part of the new liberal arts.

Conclusions

Disenchantment with technology and adverse global conditions brought about by inappropriate technological means have produced a negative reaction to the concept as a whole. What many people fail to recognize is that people create the tools and machines, people create the technologies. A curricular approach that is essential is one that allows students the opportunity to address the challenging issues of today. Including technology and technological literacy in the common core provides an opportunity for each college graduate to understand that people who are knowledgeable about their world can make a difference. A passive response is inappropriate. Letting someone else make the decisions is unacceptable. The imperatives listed are the tools, the byproducts of the skilled utilization of these tools are the creative and humanly sensitive options we must choose to survive on this planet. Our technological choices are social choices selected by well-informed and sensitive people. These well-informed people must be technologically literate people in the broadest sense.

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Social Values/Consequences of Technological Innovation

The Underside of Technological Literacy

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This paper will discuss the differences that exist between persons who are technically literate and those who are not. It will discuss the barriers to communication between groups and, finally, will suggest strategies for minimizing these communication problems and a timetable for implementation.

In any discussion of individual differences it is necessary, and dangerous, to generalize. Generalizations trivialize individuality and are subject to exceptions which, in their turn, lead readers to dismiss the generalization. The reader is asked to consider the generalized statement as a possible truism, and to judge it on its merits. It is agreed that exceptions exist for each characteristic identified. It is also noted, however, that the characteristic exists with sufficient frequency to make it noteworthy.

One further caution is made. Throughout this article reference will be made to the technically illiterate individual. This term is not used in a pejorative sense. Recognize the fact that the level of technical literacy lies on a continuum and that the terms *literate* and *illiterate* are used to distinguish between levels of literacy within and between groups.

Technically literate people, and the technically illiterate, belong to widely disparate groups; more widely separated than those who can and who cannot read. The non-reader can, with some effort, hide the inability to read. Indeed, many persons react with shock when it is discovered that a co-worker of long acquaintance is a non-reader. Our society is tending toward a non-reading base where the ability to read is *not* a criterion for success on the job. This is supported by the advent of machine intelligence, voice-prompted computers, cars, vending machines, etc., and the use of pictographs rather than letters or words on the controls of machines and appliances. The technologically illiterate, on the other hand, have nothing to hide behind. When the car would not start, the garbage disposal jams, or the refrigerator gets a wet spot under it, the technologically illiterate are completely out of their element and must rely on someone who *is* aware to solve their problem.

Two interesting side issues occur as an outgrown of this situation. First, the complexity of the device that flummoxed the illiterate came as a result of technological sophistication and, second, the illiterate feels he or she is aesthetically and intellectually superior to the one called to resolve the problem! It is at this point that the "L of a difference" come into play. At the risk of being alliterative, it is time to discuss Labor, the Lord and Lackey syndrome and the Love of Labyrinthian Linkages.

Since the beginning of humanity we have tried to find an easier way to accomplish a task. All of technology has as its premis the accomplishment of more, better, faster and easier. It is here that the word *easier* gets confused with the word *labor.* Our society aspires to an easier job; one that requires less labor. Easier is allied with white collar endeavors, labor correlates with blue collar activity. Thus our society, indeed all of the emerged and emerging nations, aspire to academic pursuits which, it is widely held, have no labor attrached to them. These are the easier forms of existence which come as a given for the college and university educated. Have you ever seen an advertisement which, urging the purchase of this insurance policy or that Certificate of Deposit, suggests doing so to provide for your child's *technical* education?

The presumption is that white collar workers do not *labor* at their jobs. Thus the college graduate feels superior to the non-college technician. They feel that they have spent four or more years in advanced academic pursuits and that they certainly have every right to be proud of their accomplishment. They believe it is obvious that their intellectual capacity exceeds that of the non-collegiate. They cannot be expected to know*everything* about the operation of every mundane appliance. Their time is spent with things of higher and greater import! The term "underside" used in the title has two different yet interrelated meanings. First, it is intended to suggest that technology is far more than machinery. If the utilization of technology could be equated with the implementation of machines, then the histories of mechanization and technology would be identical. This, however, is not the case. Technology has a "world view" that constitutes its underside and differentiates it from machinery. Most discussions of technology, nevertheless, overlook how this world view can shape persons' perceptions of themselves, their environment and society.

Second, the term "underside" refers to the undesirable consequences that can stem from the unmonitored growth of technology. Technology may have a seamy side that produces problems that are not logistical or the outcome of technical errors. The technological world view is instrumental in generating the illusion that technology is out of control, while fostering indifference about the human condition.

Technology advances a style of rationality that subverts spontaneity indigenous to human action. Because technological rationality, also known as instrumental reason, is disconnected from human desires, all measurements are believed to be standardized and precise.

The questions are: How can technology be made responsible to human initiative? In other words, how can technology be "humanized"? But before technology can be socially responsible, its apparent "affective neutrality" must be challenged, thus shattering its chimera of autonomy.

Autonomy and Production: The Social Value of Technology

Human autonomy rests not only on a mathematical method but on intervention into nature. Specifically, this method must be applied to nature. This application cannot be simply a mental calculation, for scientists must "test" their mathematical notions by intervening in nature. In other words, matter must be arranged in accordance with mathematical calculations. Once this is completed, persons are in a position to calculate and predict the results that follow from such arrangements. "Reality" is not what is present in human experience, but a possibility that stems from a mathematically calculated and physically manipulated matter (Volkmann-Schluck, 1965, p. 68).

Thus emerges a structure that treats nature technologically at the most basic level. When taking the mathematical method as the most fundamental mode of theoretical understanding, this style of cognition becomes technological. Mathematical rules not only define nature but prescribe ways of producing the material causes that yield predictable results. In short, to know how to define something mathematically is to know how to made it (Volkmann-Schluck, 1965, p. 66). In this sense, the application of mathematical constructs becomes a clever technique, as the components of the world are arranged in accordance with certain calculations and the resulting morphology serves as the basis for a technologically conceived world.

This conception places humans "above" nature. In reflective thought, a method is established that excludes the qualitative experience of nature and treats existence as a number of material components that can be arranged mathematically (Hasserl, 1963, p. 179). Mathematics is appropriate for shaping existence because the world is already conceived technologically. The "real world" is thus a product of a reflective designed theoretical model that shapes matter through calculation.

Hence, scientists are not only in a position to calculate and arrange material conditions to produce predictable results, but, conversely, of producing the conditions for attaining these findings. This conversion is one of the major elements of human autonomy and understanding the self as a law giver. But his autonomy cannot be realized unless humans can master nature. After all, as long as persons are controlled by the forces of nature, they cannot be free or autonomous. Nature thus must be forced to function according to human desires (Volkmann-Schluck, 1965, p. 68). In principle, the mathematical method, combined with the notion that nature is material, established the conditions necessary for human autonomy. Humans project desired results and calculate and arrange the material forces required to attain these ends. Nature is made to work in accordance with human designs, as human action dominates the physical world.

It must be pointed out that the projected results do not stem from human nature, for modern thought acknowledges no such phenomenon. Hence, what is projected results from an arrangement of matter that has no intrinsic existence. Therefore, everything, including humans, is treated as "stuff" or "raw material" that can be reworked to meet projected designs. Scientists intend not only to produce nature in line with preconceived calculations, but above all to "produce man" (Fink, 1974, p. 41). This leads to the view that persons are a "product" of material conditions. Thus, by projecting material results and producing material conditions, individuals also project and "produce" themselves.

The Political Enlightenment

While the scientific enlightenment led to the idea that nature is material and "indifferent stuff" to be mastered and controlled, human beings were also permitted to be autonomous and rework nature. This means that humans are in a position to take charge of their destiny. Hence, the traditions that had prescribed norms, moralities, political principles, and ethical standards must be rejected, for all socio-political institutions, which embody laws, must also originate from the individual as law giver.

This calls for political institutions whose sole legitimation depends upon a sum of individuals agreeing to abide by the rules they have established. At base, this is a consensus theory and it takes for granted the equality of all as law givers. This kind of conception of equality is quite revealing, since it demonstrates a shift from the classical Greek tradition. The Greek conception of equality was founded on the understanding that humans share a common nature. Despite their particular differences, humans share an identical essence that makes them equal (Volkmann-Schluck, 1974, p. 152). Yet characteristically, neither the Greeks nor the Romans under Greek theoretical influence nor, finally, the medievals under the sway of Plato, Aristotle, and Christianity called for practical and socio-political equality (Volkmann-Schluck, 1974, p. 154).

The demand for socio-political and practical equality emerges when the world is regarded as a material entity to be controlled and shaped according to human design. In terms of this type of equality, persons cannot have laws imposed upon them either by nature or other persons. Hence, equality does not flow from an essential human nature, but from human autonomy. All persons are equal because they are autonomous law givers and makers of their destiny through their mastery and control of nature. Thus, social institutions must be designed to guarantee human autonomy. This autonomy is expressed in numerous ways: the right of speech, assembly, pursuit of practical aims, and to make one's own destiny.

Martin Kriele suggests that the institutions designed by this political enlightenment take for granted human autonomy as a source of all law. This means, according to him, that no human can assume power over another to gain increased social status. Being autonomous, everyone is an equal source of law, and political institutions represent a consensus among autonomous individuals. As a result, the policy guarantees the rule of law and equality between persons (Kriele, 1980, p. 49).

It is no accident that the major thinkers of political enlightenment, from John Locke to John Stuart Mill, hold a similar view of political institutions: Laws represent a consensus between free individuals. Contrary to the classical Greek conception of the state as having a human nature and constituting more than a number of isolated individuals, modern theorists take for granted that society is the sum of individual interests. Thus laws reflect the ways individuals agree to interact with one another. Since a complete consensus is rarely attained, quantitative power prevails: The numerical majority constitutes a temporary "rule" with the proviso that the minority has the right to persuade the majority to change. The only right that political institutions do not permit is the abolition of human autonomy (Kriele, 1980, p. 190).

Accordingly, a specifically modern conception of ethics comes into view: utilitarianism. In this case, each individual defines what is meant by the "good life." Basically, the good life consists of the pursuit of happiness and pleasure. As long as these pursuits do not create social clashes and antagonisms, individuals are free to design their own happiness. In case of conflicts, the social good is calculated quantitatively as the greatest good for the greatest number. This numerical conception of happiness accords well with a technologically conceived world. Yet the question arises: What constitutes happiness in a technologically produced reality?

Technological Aims: Power and Possession

To control nature and change its course of development demands extensive technological power. As Hans Jonas argues, modern society believes that every technological innovation and application leads to new "discoveries" that call for newer technologies and their application in an endless cycle. Yet every new technological intervention into nature promises increased control of both nature and humans. This is the "enchanted circle" of the modern man (Fink, 1974, p. 43). Every achieved result can become a means, thatis, a material condition for the fulfillment of newer aims. Today, this is called "progress" (Jonas, 1981, p. 81).

The increasing power to control nature and to reproduce it in accordance with human designs expands the material fulfillment of human wants. Such fulfillment has assumed a particularly modern form. A brief comparison between two conceptions of fulfillment illustrates this point. In feudalism, a person was born into a particular social position. To be an aristocrat, one had to be ascribed this status by birth. The same was true of the serf. Of course, the serf's birthright excluded any hope of being an aristocrat. But with the emergence of the demand for equality, founded upon the idea of the human as an autonomous law giver, all positions become available to everyone. All persons can make themselves into anything they desire. Yet it must be noted that this self-production operates within a technological culture whose main aim is to submit nature to human controls and to liberate persons by giving them increased technical power.

When persons make their own destiny, they must also guarantee their own well-being. No social institution, position, or privilege is able to ensure an individual's survival. Because each position is open to everyone, persons must strive constantly to maintain their social position. In fact, such a striving can never cease in a technological culture (Volkmann-Schluck, 1965, p. 81). Initially, increased control over nature seems to be a panacea because more commodities, protection against the elements, and control of disease offer hope for improving the material conditions of existence. Yet it is this miracle of increased power and possessions that brings about insecurity and compels individuals to acquire more power in the form of material objects.

As is suggested, technology has no other aim but to master nature through the ever-increasing materialization of culture. On the basis of technological innovations, new and more complex technologies are produced that make the previous ones obsolete. As a result, persons who were functioning adequately within the framework supplied by earlier technological requirements, that is, they were "tooled" appropriately, become either obsolete or must strive to "retool" themselves in order to keep up with the demands of technology and ensure their survival. Since a technological conception of the world has no other aim but "progress" through expansion, no individual can ever be satisfied with his or her own level of technological sophistication. Persons must strive constantly to keep up with the ever-increasing and changing technological requirements. In principle, security can never be achieved, for at best persons can only minimize the danger of becoming obsolete and losing their means of survival.

In order to achieve a modicum of security, individuals must acquire not only the skills demanded by technology, but, additionally, material possessions. Happiness is equated with material commodities, not because their possession serves as a testimonial to human greed, but because, in a technological culture, they are thought to promote well-being. By amassing wealth, one guards against the threat of personal or social destruction. Even those who have achieved a particular status due to their expertise in some technical domain can lose their possessions. They must concentrate on maintaining their "competitive edge" or "technological competence," which is always threatened by the progress made by others toward mastering more advanced technologies. The desire to possess more as a road to happiness is ultimately a desire to attain security, not only for the present but also for the future. After all, all current possessions can be lost as a consequence of advances brought about by novel technologies. In order to avoid this loss, the future must be remade constantly by better or more efficient machinery so that any losses are minimized. While this is the source for the charge that the modern age is materialistic, a subtle shift away from human autonomy is also signaled.

In order to function in a technological culture, an individual must be made to operate according to the requirements of constantly expanding and changing technologies. The ability to acquire possessions requires that the individual submit to the dictates and aims of technology. Persons must not "make" themselves in terms of what they value and desire, but according to the strictures imposed by technology. The mastered nature, shaped into technological implements and raw material and designed initially to "liberate" persons from natural forces, has come to shape humans. Instead of being autonomous, individuals begin to regard themselves, at least in the practical arena, as a "product" of their socio-economic and technical environment.

At the base of this shift away from autonomy lies the notion that persons can shape anything to obtain a desired result and can remake themselves because they have no nature. Yet this also means that humans can be made into anything. The claim is often made that, given certain conditions, a person can be given practically any form. This is obvious considering the common feature in most modern social, psychological, and economic theories: An individual is a result or product of his or her socio-economic and environmental conditions. In this sense, the socio-economic and technological conditions assume a "life of their own," thus compelling the individual to function within or adjust to fit the requirements of the technical system. This would suggest that the technological system has become autonomous, thereby diminishing the individual.

Political Technology

Individual autonomy, political enlightenment, and the scientific enlightenment, which form the cornerstone of technological culture, are undergoing a transformation that has resulted in what Jurgen Habermas calls a "legitimation crisis" (Habernas, 1973, p. 43). While Habermas assesses this crisis in terms of the capitalist economy, a more expansive approach examines what the critical school refers to as the domination of human creativity by "instrumental reason" (McCarthy, 1978, p. 16). Such rationality is basically the technological logic depicted above. The crisis appears in two forms of the policy. The liberal form of state, characteristic of Western industrial societies, experiences this crisis as the "privatization" of political institutions. While initially these institutions were designed to serve the public, gradually they were reduced to promoting the personal or material well-being citizens. For if the basic aim of the individual in a technological culture is the acquisition of possessions, then the emphasis of political life must be to get public figures to ensure the material well-being of persons. Subsequently, politicians are called upon increasingly to fulfill the material needs of the citizenry or to do whatever it takes to prepare individuals to meet the demands imposed by new technologies. Any time they fail to fulfill these needs, politicians are no longer deemed legitimate and they are replaced. Thus, political institutions are regarded as means to be appropriated and used by contesting groups to guarantee their material fulfillment. *Political concerns are reduced to "pocketbook" issues.* The other form of state, nominally called "communism," takes "instrumental reason," or "technological logic," to its final conclusion. Stated simply, everything is either a technical means or a result of a technologically shaped world. In this sense, humans are treated as both a means for constructing the material conditions necessary for technological progress and a product of these circumstances. Such products are not only predicated on knowledge about material conditions but, conversely, conditions can be established that yield a particular result. Fundamentally, this represents an effort to build a utopian society conceived technologically. To build such a state and to "create" the "new man" appropriate for this polity, calls for a "political technocracy."

What is the function of a political technocracy in the current historical period? First since the laim is made that everything, including human consciousness and social institutions, is a product of material conditions, then the establishment of new conditions would be necessary to bring about future institutions. Second, since these institutions are the result of material conditions, those who know these conditions and how to change them for a "better" future must be free from institutional restraints. Most often, it is understood that scientific and technological complexities are not accessible to the general public. Hence, there must be a political technocracy with the knowledge necessary to establish the material conditions that would result in a radically new, utopian society. Such a technocracy must be able to redesign the material processes in every area of social life. And third, this political technocracy must consist of elites who are in charge of planning the future. Since the current material conditions are not yet adequate for realizing a utopia, these elites must not be hindered by political institutions that stress human freedom. Only when the proper material conditions are established will "true liberation" of humanity be possible because science must be able to master nature, including the human side of life (Kriele, 1980, p. 204).

These political elites, armed with scientific knowledge, have a historical mission to use all the available means, including humans, to achieve the desired free society. But with this there appears an undemocratic form of "leadership," because allegedly only a few persons have the scientific knowledge required to shape the social world. These leaders are the only autonomous beings and outlive the destiny of entire populations. The liberation and autonomy of the masses is postponed until the political technocrats have established the appropriate conditions for creating the new man (Albert & Hahnel, 1981, p. 77).

In principle, the political trend toward technocracy and "material fulfillment" is a sign that politics is being surrendered to the scientific-technological enlightenment and its promise to liberate society. This can be seen as an effort to fulfill the promise of two enlightenments: complete human autonomy and mastery over every facet of the environment. Since these promises have not yet been fulfilled, the modern age is caught between two histories (Schabert, p. 225). Although at different levels, both histories are implicit in each other's develoment. The first history understands humans to be "self-creating" and autonomous beings, who notonly create themselves--having no specific nature--but reduce nature to matter and recreate the environment. The second history represents the attempt to realize the first.

Such efforts inhere to technological progress and procurement of technical power. Since the mastery of nature has not yet been achieved, the first history has been postponed and projected toward the future as a utopian society. Its realization consists of a struggle by a scientifically enlightened political technology to use any means possible to bring about a technologically constructed polity.

Technology and Development

The price of social structural and technological development is telecommunication. Telecommunication exercises a powerful impact on all societal, subsystems by affecting the ways they fulfill their traditional functions, particularly the way change is understood. This power to alter human temporarily has been described by Emilio Filippi as a central feature of technology "transfer" in developing countries. As he writes:

> The telecommunication and computer revolutions on the one hand bring people close together and on the other isolate them. They bring them closer because simultaneously the world over we are aware of what is happening elsewhere. But at the same time the manipulation of these mechanics--the "mission control," if you will--that manages all of this isolates human beings. It converts them into objects of communication, not subjects of communication. This is a dramatic dehumanization. (Filippi, 1983, p.39)

As soon as information is disclosed, a type of telecommunication public is created, as a common knowledge base is necessary for messages to be comprehended (Galtung, 1983). Thus, the global simultaneity accompanying telecommunication accelerates expectations that may or may not be compatible with the performance of local social functions vital to developing countries. In other words, the social premise of what others are suppose to know changes the dimensions of experience and action (Luhmann, 1982, p. 271). Because all persons are supposed to be a part of the telecommunication order, they are assumed to share a common knowledge base.

The global communication industry presents a Janus face. Although telecommunication establishes a global society, at the same time separate spheres of activity are created and reinforced. The results are twofold: any individualized interpretation of the meaning of communication is absent, as any one version becomes but a component in a global mystery play, while the interdependence of interpretations is increased.

This is not the philosophers' trap of the contradiction between the universal and the particular, but rather the process whereby the particular is deprecated because it is not universal. Thus, telecommunication may be viewed as creating alienation in the form of communicative incompetence, as persons are treated as objects rather than subjects. Alienation is a process whereby activity is channeled into nominally independent spheres, with each of these domains subordinated to a scheme dictated by the telecommunication order. The chief effect of this on developing countries is a contraction of their experiential horizons that seriously limits the range of available social, cultural, economic, and political possibilities, thus thwarting future development. A particular society, in this sense, is subordinated to the norms operating to organize the global order.

The issue of "underdeveloped countries" has become volatile within the framework of a global communication system (Luhmann, 1982, pp. 289-323). Accordingly, communicative incompetence is a process within the structure of a global communication system, whereby the particular is transformed into the universal. Simply put, the modern global communication industry has as its defining characteristics the socialization or universalization of the world. Each society is effectively particular, yet only within the technologically socialized totality. Furthermore, each attempts to realize the universal in its activity by generalizing what it does to the social totality.

Thus, communication technology does not represent a limited form of consciousness within a given social formation but is the very structure of global functional differentiation. The demand for totality built into its structure becomes the demand for a universal truth. Yet the resulting alienation cannot be overcome without a redefinition of the task of theory, specifically communication theory and a thoughtful consideration of the aim of technological litearcy.

Intercultural Communication and Technology Transfer

From the standpoint of intercultural communication, an important problem relates to the way in which technology is understood and subsequently transmitted to recipient cultures. The central difficulty is that technology's current mode of rational-scientific legitimation encourages a style of intercultural delivery and implementation that is insensitive to cultural exigencies and, thus, subverts existing social meanings and practices. In its present form, the intercultural transfer of technology presupposes a model of communication that is linear and asymmetrical. This source of bias operates at both the level of technical knowledge and cultural meanings. The implications of this become clear when it is illustrated how technology is interpreted and introduced across cultures.

Because of its scientific status, technology is thought to be abstract and thus essentially independent of the contingencies associated with human social interaction. Because technology is rooted in scientific detachment, the values implicit in it are assumed to have universal validity. Hence, technology is endowed with an "objective" appearance, which encourages the belief that it represents pure or rational knowledge. In short, technology appears to have a destiny of its own. Additionally, its a priori, rationalist presuppositions encourage donor nations to believe that so-called developing ones can be drawn unproblematically into the global history outlined by a technical culture. This conviction elevates the technological competence possessed by donor nations to an abstract standard, against which cultural self-worth is assessed. The view of technological competence held by donor nations leads them to practice a tutelary commercialism with respect to the diffusion of their technologies around the world.

This commodifying of technological (literacy) competence distorts the historical experience and self-regard of recipient groups by shaping their cognitive categories according to the demands of technological reason. Because the political economy of the information age is fueld by knowledge and ideas, the production and use of technology presupposes that recipient societies have been socialized appropriately to understand technological values and imperatives.

Market domination of intellectual raw materials completes the cycle necessary for information commodity exchange. Although donor countries tend to monopolize technical knowledge, a small group of trained persons in recipient countries is essential for providing the linkages necessary for technological transfer. Yet the ever present indebtedness, if not unfailing allegiance, of the overseas educated elite to their mentors--educationally, technically, and fiscally--ensures a stable free-flow framework for the information economy. The result of this is cultural domination by a select few who possess the information required to operate a technological society.

Technological mastery tacitly assumes cultural chauvinism, however benevolent. Cultural intervention, through knowledge transfer, includes not simply the diffusion of technical material and trained scientists, it also involves the diffusion of culturally specific meanings and historically acquired structural interpretations of reality that under pin technology. To export technology is to export meaning: To export meaning is to export culture and history. Obviously, as long as the standards of development are set unilaterally by the "developed" nations, conflict will persist between the countries that "have arrived" and those that are perpetually "on the way."

Since every human being lives in a cultural system of relevances, knowledge about a society's values is integral for planning a technology transfer strategy. Before human science can act responsibly in the world community, the cultural presuppositions that influence the process of technological transfer must be identified. Interculturally competent communication of technology requires that the system of relevance assumed by technology must be clarified; the system of relevance operative within the recipient population must be assessed; and these systems must be aligned. These conditions must be satisfied if technology transfer is to respect the cultural integrity of developing nations. Clearly, the objective of communicatively competent technology transfer is to avoid the one-sided imposition of foreign values upon the recipient culture. Yet only when technologies are understood as vehicles of meaning can the vicious cycle of cultural domination and lopsided development be broken, which is endemic to many of the current technical assistance programs.

The concept of "relevance" designates a composite of values, their interconnectedness, and the functions they have in a society. Relevance is "what matters" to a specific socio-cultural group, including the history of that group's past commitments and future possibilities. Relevance functions to determine which facts, events, or problems are treated as valuable and to provide a scheme of interpretation that specifies the parameters of meaningful behavior and discourse. Donor nations can be responsive and responsible to another culture only if they adequately understand their own system of relevances and, accordingly, recognize how it affects another culture. The possibility for successful international communication transactions rests upon establishing congruence between interculturally pertinent relevances. This means that a common scheme of interpretation and orientation must be found, one shared by the deliverer of a technology and its receiver. In fact, intercultural relevance is the key criterion for enhancing technology transfer in the international community.

It must be remembered that technology does not have to be an irrestible force that undermines a culture's identify; however, its present abstract and reified power can seriously undermine a recipient society. Therefore, a rational responsible attitude toward the "problem" of technology transfer requires that the system of relevancies presupposed by technology by examined in light of the existing cultural standards of the recipient. In other words, technology must be implmented within the social and cultural "space" offered by a recipient society. Accomplishing this difficult task requires a polycentric viewpoint that is sensitive to the meaning of technology within the relevance framework of a recipient culture.

What is to be Done: Social-Cultural Receptivity Index (SCRI)

Technology has a compelling character because of the scientific assumption upon which it is predicated, particularly the mode of communication that is assumed to exist between persons and machines. Today this is known as instrumental communication, which eliminates "communicative competence." Communicative competence is the ability of persons to communicate the pragmatic intentions and social conditions that make behavior intelligible. Communicative competence, however, is not necessarily technological. In the case of technology transfer of the problem of internal brain-drain, more sophisticated nations do not export communicative competence but *discursive domination.*

From the standpoint of effecting the mediation of technology, the central issue is not the fact of technology's diffusion to nations around the world but the way in which the technology is interpreted and implemented. Consequently, it is a problem of gauging and adjusting for the probable interactions between the innovative and social-cultural environment. This is principally a question of the communication practices associated with the technology and its way of influencing social arrangements. The practical premise asserts that technical considerations and determinations need to be supplemented by a social-cultural problem-solving orientation that is adequately sensitive to cultural/environmental differences, in such a way that it can provide guidance with respect to existing cultural meanings and practices. The deliverer's sense of relevance must be coordinated and reconciled with the recipient's frame of reference. Only in this way will the two very different social realities achieve a measure of collaborative interaction that pivots upon the joint management of cultural differences.

The immediacy of the natural environment is so much taken for granted that we never pay attention to it, even though it sustains all of our biological necessities and physical functions. This unnoted "immediacy" applies equally in the case of the cultural environment: we do not fact it; we are encompassed by it and engaged by it. The various factors composing the natural environment become visible only when they for some reason become an object of concern, especially when something fails to perform properly or they somehow obstruct our normal functions. Similarly, the cultural environment becomes an object of concern when the interconnections of its symbolic design do not apply in the accustomed way. In such situations, the cultural system, or rather the agents embraced by it encounter 'novelty,' 'uncertainty,' or 'nonsensicality.' It should be kept in mind that technology transfer entails the intentional and purposive introduction of novel configurations into a local cultural system.

The various symbolic designs make up a cultural eco-system which, while taken for granted in our daily activities, is never confronted directly; all activities, events, and behaviors appear in its context. Even the 'natural environment' is incorporated into this framework. And this framework becomes manifest and effectual in the various cultural artifacts and institutions, ranging from the religious and mythological, to the professional and scientific, and to social roles and the daily stylization of human encounters.

SCRI has two principal roles: (1) it provides a taxonomic framework of meaning that incorporated the core dimensions of cross-cultural encounters pertinent to technology and innovation diffusion activities. Therefore, it furthers the identification of the important components of the frame of reference establishing the cultural environment. (2) It serves heuristically to draw the attention of planners, designers, and implementers, to the possible domains of socio-cultural environmental impact. Thus, it contributes to the capacity of to "size up" and to "read" the situation, therefore alerting us to the likely combination of socio-cultural interactions that might be encountered.

The general nature of the communication relationship between technology/information transfer activities and recipient characteristics can be formulated in the following way. While, on the one side, place characteristics are a consequence of the recipient's level of development and, on the other side, the delivery strategies and implementation practices and objectives are established by the policy and program goals of the deliverer, this independence of the two parties becomes transformed into irreversible interdependence at the point of delivery; regardless of the previous history of the recipient nation and the institutional history and orientation of the deliverer, the two become "locked" irrevocably into a reciprocal communication structure, upon which depends the possibility, the effectiveness, the punctuality, and the sustainment/durability of the technology exchange undertaking.

Emphasis is placed upon locating possibilities for mutual intersections along the two systems of cultural designs. by its very nature, technology mediates and is mediated by the socio-cultural system into which it is being introduced--vis., it effects changes and is changed; consequently, the objective is to raise the inevitable intercombination with a communication environment to an *explicit domain of analysis* in order to make possible the maximal anticipation of consequences. In this setting, the innovation and its interaction with the socio-cultural environment is the chief focus of research consideration. Adopter characteristics and determinants as well as, it should be noted, the characteristics and determinants affecting the deliverer and the deliver's sense of relevance are treated as partof the interaction pattern produced by the innovation; this 'problematizing' of the innovation established the ground for explicit cultural mediation of the technology.

The following roster contains the dimensions along which the cultural mediation of the technology is to be pursued and, it should be emphasized, pursued across the symbolic designs of both deliver and recipient cultural sensibilities.

SCRI Dimensions

Global Factors.

1. Social organization of space and place; e.g. central place, prominent natural features, the articulation of social roles and status relative to locally significant landscape.
2. Constraints upon aspirations; e.g. educational (formal) and traditional levels and type, adaptability of local mind-set to the technology, local goals and expectations.
3. Value compositions; e.g. prevailing beliefs and myths, cherished virtues and practices, constructs like common sense, propriety, justice, and the like.
4. Ritual organization of social life; e.g. puntuality, ceremony, hierarchy, and psychological adjustment.
5. Cultural integration of social organization; e.g. relationship between cultural outlook, heritage, values, and beliefs and existing role divisions, status, social place of different generations and genders, political forms.
6. Cultural aesthetics; e.g. concepts of beauty, decoration, and appropriateness, aesthetics of the physical environment, also personal adornment, perception of symbolic designs, artistic forms.

Social Communication Factors.

1. Nonlinguistic expression: bodily expressiveness, physical regimen and rhythms, dietary and culinary assumptions, tact.
2. Psychological culture; emotive expression, linguistic modulation of emotion, manners, appropriateness, sociability, timing, trust.
3. Conceptual/credal constellations; differences between groups, unchallengeable beliefs, unmentionable topics, world-view presuppositions.
4. Linguistic culture; cultural face and language, verbal expressions of equality, superiority, uncertainty, disagreement, and the like.
5. Interpretative matrix; the other's likely assumptions and interpretations of one's statements and actions; how one's culture, history and social position is read from the other's viewpoint.

In short, both the global and the more apparent communication specific factors affect the delivery and enactment of the knowledge transfer. Often it is a question of the mutual adjustment of expectations about the other that takes the form of negotiating cultural differences. For the deliver, continual monitoring and careful evaluation are crucial for the gradual development of trust and collaboration. It is important that the recipient have a way to see that it is the recipient's own best interest that motivates the innovation, and consequently that the technology "makes sense" within the recipient's own cultural understanding. To my mind this is the "stuff" of developing technological literacy.

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Impacts of Technology

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A discipline within the education community has been transforming before our eyes. Tremendous strides have taken place within the last few years to create the discipline known as Technology Education--The New Basic. Technology Education has proported to be an action based program that is concerned with the technical means, their evolution, utilization and significance with industry. . .*Technology Education: A Perspective on Implementation (1985).*

A second thrust of the technology education movement has been to study impacts of technology.

> . . .with industry, its organization, personnel, systems, techniques, resources, products, and their social/cultural impact (*Technology Education: A Perspective on Implementation*, 1985).

Needless to say, there is much in the literature that suggests the education community should be addressing the topic of technology and its impact. In addition to the definition provided earlier, the following are examples of the call for the study of technology and its impact:

> Technology: All students should study technology, the history of man's use of tools, how science and technology have been joined, and the ethical and social issues technology has raised (*High School--A Report on Secondary Education in America*, 1983, p. 304).

> Contributing to technological literacy is an understanding of: (1) the historical role of technology in human development, (2) the relationship between technological decisions and human values, (3) the benefits and risks of choosing technologies, (4) the changes occurring in current technology, and (5) an understanding of technology assessment as a method for influencing the choice of future technologies (*Educating Citizens for the 21st Century*, 1983, p. 74).

Despite the national call for the study of impacts of technology, the technology education community has been slow in providing direction. Reasons for this lack of study are many, however, some of the more prominent reasons are as follows:

1. The lack of understanding of what the study of impacts may involve.
2. Lack of perceived benefit.
3. No role model to work from.
4. The lack of resource materials for the absolute novice, to have this topic become a viable area to study in the technology education programs across the nation.

Granted many prior efforts have come to fruition that address this issue; i.e. *The Man Made World*, *Science-Technology-Society*, *You, Me and Technology*, and etc. However, these efforts have been primarily targeted towards the liberal arts curriculum.

Thus the need for the Practical Arts and Vocational Community to address these issues.

The study here is to go beyond the mere existence of 'facts' artifacts, inventions or applications. It is necessary to probe more deeply into the logic, the human condition, the societal dimension or consequences, the ethics, legal or common good. Such questions might be along the lines of:

1. What are the alternatives?
2. What is the social impact?
3. What is the environmental impact?
4. Who should be involved in the decision?
5. What are the principles of science and/or mathe matics involved?
6. What role has the technology or the innovation played?
7. What is the long-range impact?

8. What are the ethical, moral and legal issues associated with the technology?
9. Who should pay?
10. What if?

The questions should provide the means for a more holistic approach to the study of a technology. Such questions should be presented and used to probe beyond the surface and not to develop a negative frame of reference for the study. The goal of such points of inquiry with students is to open their thought processes and to develop their inquisitiveness related to technology with respect to a wise variety of issues--technical, social, environmental, financial, ethical, etc." (Maley, 1987).

This type of curricular framework coupled with the technical skill development that the vocational community has enjoyed for years make for a marriage of unprecedented benefit to the growth of our nation. So it is that a manual entitled *Impacts of Technology* has been developed. It is the author's hope and intention that this manual will allow the reader to become familiar with what the study of Impacts of Technology is, and supply enough resource material so that one could develop curriculum on the topic of *Impacts of Technology.*

The manual *Impacts of Technology* has been written using the LAP (Learning Activity Packet) format, so that it could not only serve as a place to go for information, but also has activities built in. A total of 32 activities have been included. The topics covered in this manual are, as follows:

Titles of Learning Activity Packets

LAP#	Title	Page #
1	How and Why Technology Has Impacted Our Lives	1
2	Types of Impacts	5
3	Environmental Impacts	12
4	Technical Impacts	16
5	Financial Impacts	19
6	Social Impacts	22
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Notes

The *Impacts of Technology* manual is currently being considered for publication; however, further information can be secured by contacting the author, Mr. Jerry Balistreri.

Christian Relational Theology as a Framework For Assessing the Moral and Social Implications of Technology

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Human needs--physical, mental, emotional and spiritual--have remained stable over the centuries of technological evolution, but how we attempt to meet these needs has changed phenomenonally. Although those changes may be most obvious in the physical realm, they exist in each realm (Arnett & Ramer).

Some form of technology is necessary for human survival. Every available archaelogical evidence indicates that humans have always used technology. A recent article in *Scientific American* documents that even the flint tools used by early humans are effecient and effective instruments. As far back as we know, humans have used technology to alter the natural environment. Indeed, there is no evidence that we can survive without some degree of technology. Even the most primitive of cultures use systems of technology in order to provide food, clothing and shelter as well as communication and other activities. An important distinction, though, is that there is a difference in the degree of technology necessary for survival and the degree necessary for convenience or luxury. Any degree of technology affects how we relate to our surroundings and to one another as human.

As we approach the 21st century and the implications of a post-industrial economy become even more pronounced, our culture will have an increased need for the assessment of technology. The goal of such evaluation is not an ultimate judgement on technology. Such seems unfeasible, perhaps impossible. What is feasible, and we believe, imperative, is a very deliberate, systematic appraisal of technology.

Such an appraisal is justified by several reasons: technology involves and affects everyone; technology demonstrates tremendous potential; technology involves values in a manner which is simultaneously covert and dramatic; the pace of technological development appears to be increasing to a degree that is at least startling and at most intimidating. Any value-laden force which demonstrates such powerful and ubiquitous results demands careful contemplation. To fail to evaluate technology is to play a game of Blind Man's Bluff with unprecedented implications.

Evaluation Frameworks

Various frameworks are available for such assessment. An economic model with its standard of efficiency; a socio-political model with its standard of control and justice; a cultural model which seeks the preservation of ethnic identity; a mechanical model which attempts to construct the ultimate machine--one which calls for no human intervention; a bio-medical model which seeks adequate health to pursue desired activities; and an ethical model that seeks to know what technology is right or wrong, good or bad.

Although these various frameworks are available, the economic model seems to be most often used. This model purports to assess technology by adding the benefits and subtracting the costs. Such a model is used by manufacturers to determine whether or not to replace human workers with computer controlled machines. It is also used frequently by government agencies and several other groups. Costs, however, are often hidden. At other times, a dollar value is hard to apply, as in the case of relationships.

If a community decides to drain a fresh water swamp at the outskirts of a town to build a factory for employment, what is the true value of the lost recreation and wildlife area? Suppose that two years later it is discovered that the swamp was a natural water filter for the community's water supply. Now what is the cost? Thus the choice, although including economic considerations, is also one of relationship of a community to a natural fresh water habitat and a workplace for its citizens. Monsma and others (1986) point out the limitations of economic assessment, particularly noting that such assessment is often considered in such a narrow sense that it seldom even provides an accurate assessment of material factors.

While each model has its own contributions to make, the above example illustrates that each is limited. What we end up with are various conclusions about technology, developed from a narrow perspective that fails to consider the wholistic nature of technology and the pervasiveness of its influence. The assessment of technology must address the gamut of effects.

The validity of an evaluational framework ultimately hinges upon its ability to satisfactorily answer the questions asked (considered to be important) by the evaluator. In regard to technology, those questions will vary with the world view of the particular evaluator. Hence the Honda accountant in Tokyo may consider very different criteria than does the second shift machine operator at the Honda plant in Marysville, Ohio. Nonetheless, each agree that some kind of evaluation is in order. Beyond the implied narrow perspective of these two, though, we argue for a larger based evaluation of technology.

Social and Ethical

There can be no question that the social and ethical implications must be examined. New situations precipitated by advancing technology, such as artificial insemination, surrogate mothering and genetic engineering, call for value decisions and are altering our culture, including the way we relate to one another as human.

We have only recently begun to realize the complexity of technological systems and their influence on world cultures. To assess this influence, we must begin to understand two important considerations. The first is that the physical objects that a culture produces are a reflection of that culture's values. Secondly, we need to recognize that the products of technology, the tangibles, also have an effect upon the culture which produced them. For example, the automobile is not only a technological product of our culture, but has had a deep influence upon our culture. Also, we should note that the processes of production and service also affect a sociey.

This paper will demonstrate that technology can be evaluated based on the extent to which relationships between technology, humans, and environment are maintained. More specifically, the paper will bring evidence to light that supports the notion that a Christian relational theology is an appropriate model to assess the moral and social impacts of technology.

Christian Relational Theology

Let us first of all define what we mean by "Christian relational theology." If you are expecting an elaborate, complicated, philosophical statement, you will be disappointed. Instead, our concept is quite simple and includes three basic concepts from the teachings of Christ. One, all humans are in relation. That is, all are "neighbors". Whether the relationship with my neighbor is positive or negative, it still exists. It also exists regardless of the degree to which I am aware of it. Second, "Love your neighbor as yourself." Finally, "Treat others as you would have them treat you." While the simplicity of these concepts may suggest that you are in a primary age Sunday school class, the application of those concepts has a compelling power and rigor that exceeds the capabilities of the greatest philosopher.

The notion of a Christian relational world view as a basis for evaluating technology stands upon two ideas that seem almost truistic. One is that a moral framework seems to be a logical choice for evaluating moral impacts. Most people are religious and in our country as well as many others, Christianity continues to be the most dominant religion. Recent events have pointed out to us that religious people commit immoral acts (as do non-religious people) but have also pointed out to us that the American public still makes moral judgement. Even the dedicated church-avoiders have been known to drop their support of presidential candidates because of "alleged social indiscretions." To ignore the framework used by the population in making value decisions is at best, unsound as a governing principe. More seriously, it ignores a natural choice for assessment.

Religion and other forms of philosophy have historically been the bases for making moral evaluations. Any religion then that claims to present a moral standard--a set of principles that identifies what is desirable and/or undesirable in terms of human behavior--seems a potential basis for evaluating moral implications. Even though we may reject a partiular religion as a matter of personal faith or choice, when we consider it as a potential model, we are obligated to judge it based upon the principles which it teaches. Therefore a religion which stresses desirable standards of human behavior has merit for evaluating moral implications.

While the moral application may be often admitted, dealing with social impacts is seldom seen as fitting within the parameters of religion. We think this is due to a misconception of religion in general and Christianity in particular. This misconception may be within or without the Christian community.

Any scheme which purports to address social issues, by definition, must include human relations. *Webster's New World Dictionary* (1964) defines "social" as "having to do with human beings living together as a group in a situation requiring that they have dealings with one another." If that does not involve human relations, what does?

But instead of this, twentieth century Christians tend to think in moral terms--an act is either right or wrong. Occasionally, Christians will think in valuative terms--an act or an object is then good or bad. We think that a better approach would be to ask, "How does this behavior, act or object affect my relationship with others?" Although Christians have argued about the correct interpretation of Christology since the time of Christ, the one issue that is commonly agreed upon is the centrality of relationships. This paper assumes that whether people consider their interpretation to be conservative or liberal, that correct relationship with fellow humans, with the environment, and with one's belief system--that is, living in good conscience--are at the center of Christianity. This then, provides a sound basis for judging the acceptability of social implications--Does the technology promote desirable human relations?

This paper will explore the idea of technological assessment based upon some very basic and simple principles of Christian relation. The notion of being in relationship requires the making of choices, and being in Christian relationship infers that the individual chooses wholeness over fragmentation. Consideration of relation based solely on economic factors is narrow to a debilitating degree. Making relational choices requires knowledge beyond the bottom line of a ledger sheet. A reductionist paradigm simply cannot address the human issues of technology. To say that unemployment remained stable during the third quarter ignores the human suffering of unemployed or under-employed families and the nature of work engaged in by the employed. Christianity maintains that these aspects are important and that desirable relational choices are built around accurate analysis of both divine and natural information.

This notion of volition is at the center of the advertising industry which attempts to convince people to make particular decisions about particular products. That industry rarely asks consumers to consider the variety of implications bound up in purchasing and using those products, however. An individual or community aware and informed of the consequences of a decision will usually choose the way that will protect the relationships most important to them.

This idea of technology assessment assumes that individuals have volition in the matters of technology; that Christianity and technology are both relational physically and metaphysically; that there are various valid models of technology assessment and Christian-relational is one; and that informed, wholistic decisions are more likely to foster relationships. Any socio-cultural model that purports to evaluate technology must deal with relationships.

A point often argued is that technology and Christianity do not mix. It is not surprising that non-Christians, or non-religious people would argue this. But for Christians to accept such an idea indicates that they have failed to grasp the Messiah's intent that His teachings were intended to govern every aspect of His disciple's lives. It is this failure to rigorously apply Christian principles that is responsible for the past failings of Christendom to be, in practice as well as doctrine, the kingdom which Christ came to establish. This failure demonstrates a lack of appreciation for the fact that correct relationships are at the center of our function as God's people on earth. Therefore, the study of the relationships of human beings to their tool systems and how they interact with the environment should be of utmost concern to twentieth century Christians. But the Christian framework also has validity for non-Christians interested in human consequences of technology.

This concern with human issues has been voiced by many, including Ely Chinoy.

> An affluent society, however, can afford to concern itself in new ways with the human consequences of technology, to make choices between cost, let us say, or efficiency, and the impact of the job experience upon the worker . . . engineers and managers, however, have rarely concerned themselves with the human or social consequences of technology . . . Shall concern with production and cost continue to take priority over more immediate human values? (1964, pp. 76-77, 80)

Chinoy's statements and question focus sharply on both the opportunity and responsibility that we have as citizens in a land of plenty. No longer are we concerned only with technology for survival, we both enjoy and are afflicted by technology that offers both convenience and luxury. Such dissonance points out the need for deliberative evaluation of our technology, including its social impact. We maintain that Chinoy's observations demonstrate that consideration of others would change the practice of technology. In some cases, engineers have designed work roles for others that they themselves would abhor. Managers have directed workers in patterns of work that they themselves could not tolerate. Such indicates a lack of neighborliness, a failure to treat others as they would be treated, an absence of positive relationship.

An Illustration

To perceive the influence of technology on human relations requires that we go beyond an object-centered view. Simply noting that Uncle Fred and Aunt Agnes can drive their car up to Vermont and visit the grandchildren does not provide a large enough framework. We may also note that although the automobile allows them to maintain contact with the extended family, it may increase the likelihood that the extended family will be distanced. Although we may certainly begin to discuss the impact of the automobile on their relationship with the grandchildren in Vermont, that allows neither an adequate assessment of the automobile or of Aunt Agnes and Uncle Fred.

Agnes and Fred, in addition to being involved in a consumer role, are also involved in relationships stemming from the design, production and servicing of the automobile.

Each designer involved in the manufacture of the car is inextricably linked in a relationship to the consumer. (Try removing the front oil pan plug on a '78 Fairmont when the car is on a lift or changing spark plugs in an '84 Corvette.) Whether by fault or oversight, the engineers who designed the Ford Pinto had a relationship with those individuals killed or seriously injured in flaming rear-end collisions. There is no reason to believe that there was a conspiracy on the part of the engineers against the lives of Pinto owners. More likely, the issue is one of oversight. But is not such oversight less likely when the engineer considers Uncle Fred and Aunt Agnes to be involved in an important relationship with her or him? Conversely, there is also a relationship between the engineers of the safety harness and/or infant restainers which have saved the lives of thousands of people. Also, manufacturers who devote much time and money to make vehicles more comfortable indicate a positive degree of relationship with the consumer. (Incidently, the idea of designer responsibility historically precedes Christian culture. At least as early as Assyrian culture, if a building collapsed and killed its occupants, both architect and contractor were put to death.)

In addition to the designers, the producers of a manufactured or constructed object also exist in a relationship to consumers and designers. By following standards conscientiously and noting design flaws, workers are able to maintain a "faithful" relationship with both the designer and consumer, one which conveys a sense of honesty, reliability and dependability. On the other hand, the tire builder who fails to follow specs, or deliberately multitates the design, violates the honor of that relationship.

Correspondingly, corporate managers who gouge prices, monopolize trade, discriminate unfairly in hiring and firing practices, defraud consumers and otherwise fail to practice faithfulness, act in a way to destroy human relationships.

Finally, consumers who refuse to pay for merchandise, neglect or abuse products, defraud the producer or servicer and do not act faithfully in other ways, also act in a way to destroy human relationships.

Everyone involved in the system, as employer, employee, consumer, etc., is involved in relationship to others in the system.

The point, up to this point, is not to blame technology per se for all broken relationships described above. Rather, the point is that technology involves people in relationships. The responsibility of technology, or more accurately the responsibility of those who employ technology, accrues from the degree to which a technology encourages or hinders the cultivation of human relationships. This principle is operant not only in the object but also in the processes inextricably linked to the object.

Mass private ownership of the automobile demands a system of production that involves certain inevitable implications for human relationships. That system, mass production, is the only means of providing semi-affordable automobiles, supplying us with high quality, uniform products at a low price. That system, by definition, also involves processes which separate workers socially and reduce the bulk of work to highly repetitive tasks. Confined to small work stations, restricted in social contact and creative activity, many workers identify with the one who said, "The things I like best about my job are quitting time, pay day, days off and vacations" (Chinoy, 1964, p. 75).

By purchasing the product, I participate in the process by which it is produced and am therefore, in relationship to the workers. As such, I benefit from the designers/managers who wish to provide me with an affordable car, but reinforce a concept of production that forces others in my relational network to work at jobs that are frustrating, monotonous and unrewarding. I also participate in the systems which support the ownership and use of the automobile.

Private ownership of automobiles necessitates a system of fuel procurement and distribution which has, at times, promoted exploitation of other countries. Some writers have dealt with this exploitation of the individual and of cultures, often from quite different perspectives.

Jacque Ellul and Samuel C. Florman are definitely not cellmates in their view on the nature of technology. Yet both agree that the concept of creativity is central to the human persona. That view is not a new one. E. F. Schumacher (1973) quotes Thomas Aquinas as stating that the human is "a being with brains and hands and enjoys nothing more than to be creatively, usefully, productively engaged with both his hands and his brains." In dour reflection on that description, Schumacher laments that modern technology is "most successful in reducing or even eliminating skillful productive work of human hands in touch with real materials or one kind or another" (p. 149).

Whether or not one agrees with Schumacher, the issue provides very pertinent questions. To what degree does technology as currently practiced increase the potential of humans to be creative? Which individuals benefit most? Least? What individuals have less and less opportunity for creativity as a result of model technology? To what extent does modal technology enhance the relationships of designer *object* producer? Marketer/consumer?

Our model technology of manufacturing makes great physical demands with minimal financial, emotional and spiritual reward of a maximum of the people involved; offering them abysmally limited opportunities for creative engagement, social intercourse and connectedness with designers and consumers.

Our modal technology of communicating provides maximum coverage of the views of a tiny proportion of the population with control of communication by a very few. There is a parallel between the control of information and the control of money.

Our modal technology of finance lends itself to maximum control by the smallest numbers. According to the *Columbus Dispatch* a few weeks ago, .5% of our population made 27% of the earned income for 1986 and controlled 40% of the nation's capital. Point five percent. Such situations seem inevitable in our system of investment/production.

Also inevitable in an ethos of the most goods for the least price is a distancing of relationships. Designers plan products and never taste and smell the production floor. Producers supervise machines and never feel the resistance of material against tool. They experience the boredom of repetition but not the joy of creation. Advertisers seduce buyers whom they never meet. Servicers repair objects in which they have no vested interest. Inevitably, there is a distancing between human/human and human/material.

As a result, creativity becomes more abstract and more privileged. We transcribe the minds of ten designers into a network of binary decisions on silicon chips, giving one person creative potential to power "x" and excluding nine others from the creative process. Even the creativity of production line problem solving becomes more cybernetic, less organic. One result of this spirallic tension is the distancing of human relationships. Having placed automation closer to the hub of technology, people are slung in centrifuge further from the creative core, further from each other.

We have chosen this system primarily because of its potential of supply cheap consumer goods. If I purchase furniture designed, produced and marketed by my neighbor, I must pay more for lower quality. Such allows a deeper relation between human:material, human:machine and human:human, but it requires a cost I am unwilling to pay. Instead, I opt for a system which provides me with high quality low cost furniture but also requires my human family to be distanced from itself, its work, its environment. Instead of working at home with the family, my neighbors work in large factories or offices. Instead of working intimately with materials, my neighbors observe them as they are shaped by machines. Instead of producing objects which involve themselves totally, my neighbors input precise quantities of detached energy. But I can have more by for less by participating in this system. Evaluated from the economic perspective folded into my hip pocket, such technology is seen positively. Evaluated from the perspective of human relationships engendered toward mutual trust, care and reward, a different valuation emerges.

Instead of continuing on the macro level, in order to illustrate how a Christian world view can be used as a basis for evaluating technology, we move to a micro-analysis--one person's observation of the telephone. Using relationships as the basis, this aspect of communication technology will be projected from the bases of inherent and applicative capabilities.

Inherently, telephone communications necessitates a system of connections--satellite, transmitters, signal receivers, relays, cables, wires, dials, etc. Involved in that, various workers are drawn into relationships with each other and with consumers. This means that some of my neighbors will work in various capacities with various materials in order to provide me with communications service.

The phone entails some sort of alerting device--necessarily one of an obtrusive nature--in order to gain the attention of the call receiver. This obtrusiveness also introduces certain aspects that affect human relationships. This means that some of my neighbors (even ones I am reluctant to acknowledge as such) will attempt to communicate with me in various capacities at various times regarding various topics. Those times and topics may or may not be conducive to relational concerns I have at particular times.

A special distinction about these situations, though, is that the way we employ the technology is more to blame than is the technology itself. An answering machine could be turned on during those times when we do not wish to be interrupted, but serious discussions and romantic moments are not always anticipated! (Not to mention the rare emergencies which interrupt them.)

A more noxious example of the modal technique presents itself at the automotive parts counter. I can hardly remember a time when I have stood in line to get a price quote on a part or the part itself without being pre-empted by a phone customer. It didn't matter that I had waited for twenty minutes, someone else could call from the convenience of home or office and receive immediate priority. In twenty years of abuse, I have only one time witnessed a worker who answered the phone and said, "I'm sorry but I have other customers in front of you. Please hold or call back in twenty minutes." I could have jumped over the counter and kissed the man's greasy ear! (Such gratitude would be hardly acceptable in a setting where real men don't even know what quiche is.)

The point here is that we can refuse to use a technological innovation in such a way that interferes with relationships but promotes them. The telephone can maintain long distance communication and interrupt personal communication. It may allow me to maintain previous relationships and avoid making new ones. It can bring emergency assistance or unwelcome intrusion. (I have yet to figure out why it's wrong to invade my privacy to obtain criminal evidence and okay to invade it to give me a limited time opportunity to purchase options on a vacation condominium in central Ohio.)

Inherent in the telephone are certain materials and processes. Humans must extract certain substances from earth and use certain processes in order to transform those into telephones, switching centers, lines and billing terminals (Human:environment). People must work in certain capacities as operators, installers, repairers. Consumers must pay bills (Human:human). Relationships between people in all categories are involved in every phase/aspect of telephone communications, even though their perceptions of the technology and of each other may vary considerably. To evaluate the social impacts of that technology, we must consider its influence on human relations.

The point of this paper is to help make plain that moral and social values are inherent in and inseperable from technology, to consider how technologies inherently and modally affect human relations and to make technological valuations based upon their ability to cultivate richer more rewarding relationships for designers, producers, consumers and servicers. Such a framework places greater emphasis on humans as served by, rather than serving technology.

Such a call seems simplistic and--some will scoff--moralistic. Keep in mind, though, that such incidents as gas tank explosions, nuclear disaster and the proposed use of neutron weapons, not to mention marital indiscretions often seem to be greeted by moral outrage--even by those who argue that morals and values are too nebulous to be useful. Not only do we believe that technology by the Golden Rule makes such incidents less likely to occur, we also believe it will offer a more responsible technological response to them if they do occur.

Our position is unabashedly Christian. Rather than attempting an assessment of technology, we have attempted to posit a framework which allows for a meaningful evaluation of moral and social implications. Any evaluative standard presents, implicitly or explicitly, a decree of what should exist. Such standards are necessarily implied in the very concept of evaluation. One cannot enforce a particular religion as the only standard but can certainly argue that a particular religion is or is not a valid standard.

Since we agree that the social and moral implications of technology ought to be evaluated and that social issues by definition are concerned with human relations, a religion that prescribes a standard for human relations becomes a viable option for evaluating social impacts of technology. Therefore, a religion that maintains that all humans are neighbors, and that each human should love neighbor as self, certainly is a compelling and stringent measure for technological evaluation.

Whether seen as simplistic and moralistic or not, this framework has dramatic statements to make about the way we use technology, the way we pursue technology, and the way we involve people in technological systems. It is our position that technology which fosters relationships of trust, care and respect is ultimately desirable technology, a serving technology. Technology which exploits and weakens human relationships, even if it incidentally provides economic adavantage to the few or to the masses, is ultimately undesirable technology.

The ability of a Christian relational theology to improve technological practice depends primarily upon the willingness of humans to consistently and vigorously apply its demands of consideration for others--to live by the Golden Rule.

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Social Consequences of Technological Innovations

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Technological change is nothing new to America. In fact, it could be argued that the very name "America" is symbolic of rapid changes in technology: how else can we explain the fact that advances in communications, navigation, and weapons made it possible for an explorer from the technologically advanced state of Genoa to accomplish in 1492 what had eluded some very capable seafarers like the Vikings for centuries? So accustomed are we to rapid change, that we sometimes fail to wonder at what is really wonderful: many of us, for example, were deeply touched by President Reagan's eloquent tribute to the Shuttle astronauts who died in last year's Challenger disaster. The poem recited by the President was written by a young aviator who was killed flying a World War I plane:

[For I have] slipped the surly bonds of earth/and touched the face of God.

That plane was constructed of balsa wood and canvas. Ronald Reagan was a young small boy then. Yet there he was paying tribute--in a timeless way--to brave Americans who challenged the heavens in the latest product of a technologically sophisticated aerospace industry. All this has occurred within one man's lifetime. But far from suffering "future shock," Americans seem to expect that all problems will yield to technological solutions. We seem not so much to be shocked by the future as to be shocked when the future fails to proceed--on schedule, as planned, and flawlessly. Technology can be seen as a means to expand our range, to extend our powers, to realize goals that are consistent with our values. What, of course, it cannot do is to substitute for those values. Courage--like that of the World War I flyer and the Shuttle astronauts--is not replaceable.

The challenge of change is being felt throughout our society and certainly throughout this administration. Competitiveness is the watchword. Our federal education and training programs are constantly being re-evaluated in the light of changing conditions. Much of the debate about programs is reduced, unfortunately, to funding levels. But I have shared with Congressional committees and with educators and industry leaders my firm conviction that the competitive challenges we face are not to be met simply by spending more at the federal level. It is entirely possible, in fact, that excessive federal spending--with all the necessary regulation and bureaucratic oversight--may cause us as a nation to become less adaptive to change and less competitive. There are areas in which the federal government has a genuine role to play. By encouraging competition--not only in the market place of goods and services, but also in the market place of ideas--the federal government can foster the qualities which are hallmark of a competitive society.

My office has been given statutory responsibility by Congress to coordinate federal rural education programs. We are all familiar with some of the problems frequently cited in media accounts of the crisis in rural America. When we hear of the plight of farmers losing farms, of families uprooted, we all naturally feel compassion. Our federal response should be measured one. We should seek to correct existing problems without causing new ones. Many candid observers of the crisis of rural America acknowledge that many of the problems which now cry out for solution are the direct result of *solutions* which the federal government applied to the problems of yesterday. By encouraging farmers to expand production, to lease more land in the inflationary economy of the 70's, the government set them up for a loss when inflation was brought under control--as it had to be.

The future vitality of rural America may well depend on diversification not only of products but of people. A standard argument made for the consolidated high school, for example, is that it can present more course offerings. Economies of scale is certainly a concept easily grasped. Yet the larger, more impersonal high school may have its disadvantages, too. Research suggests that bigger may not necessarily be better when it comes to school discipline and youth suicide. The sense of belonging which comes to being a part of the small community called school may itself be worth preserving. The use of satellite communications, mobile labs, and the use of electronic networks may enable the small school effectively to overcome the disadvantages of isolation and distance. This is why I would suggest, *some* federal spending cuts are less desirable than others. To cut back on funding for a space station while claiming we need to spend money in rural areas may be to lose sight of the fact that the advances in communication and miniaturization spawned by the space program are the very sort of federal aid which may best help rural America. One of the most promising--and least costly--areas for federal coordination is in the establishment and operation of resource databanks and information clearinghouses. We must recognize that such efforts are not entirely risk free. How to avoid exploitation while assuring access is a constant problem. For example, the information which showed that antelope, Oregon was an attractive community for settlement and investment was as readily available to a strange cult group as it was to industry scouts. The natural beauty and uncrowded neighborliness of much of rural American make it vulnerable as well as attractive. In another sense, mobility is an inescapable part of the American story.

That is a key point to remember: America has always been a dynamic and mobile society. A Pulitzer prize-winning book by Harvard's Bernard Bailyn recently pointed out that Great Britain was suffering a drain of brains and talent in the 18th century. The very name America was synonym for movement, for freedom, for opportunity to the struggling young farmers and workers of England, Scotland, and Wales. No amount of pressure exerted by the Crown could stem that human tide. In similar way, three famous Americans made much of their rural roots as they campaigned for the highest office in our land. Millions of Americans supported their call for a return to the values of the small town--at least as those spokesmen interpreted those values. But when the majority of Americans chose a different course, none of these three leaders returned to the rural communities that had nurtured them. This is but one example of a process that has been repeated millions of times by the famous and the not-so-famous, throughout our history. The interstates run both ways and we should not erect roadblocks to freedom.

In a free society, government cannot restrict the legitimate career and residence choices of its citizens. We may be seeing in parts of rural America a particularly acute form of a general pattern of movement. What government can do is to ease the shocks of rapid change through education and retraining and through encouraging the productive private sector to expand job opportunities.

Technological changes certainly present vigorous challenges to traditional values. It is a time of testing and of paradox. We have a generation of young people who are instantly aware of clashes in the South African township of SOWETO. But too many of them are incapable of locating South Africa, or even South Carolina, on a map. We find many high school age youngsters who are fully capable of manipulating computers, VCRS, CD players, but who might have trouble diagramming an atom. The "new basics" called for in a number of recent national reports on education reflect an urgent national need for seriousness about the business of education. It is as if some serious scholars had reviewed many of the exotic curricular innovations of the last twenty years and asked: "Where's the beef?" The result of some of these educational failures may be seen in chronic unemployment and underemployment in some central cities as well as in rural areas. For many of our young people, the promise of affluence and access to secure, productive jobs spurred by government uplift programs has been cruelly unfulfilled. They see opporutnities limited for lack of basic skills. Yet, the classified sections and technical trade journals call out: help wanted! We face real dangers of social unrest as skilled immigrants seek and get the good jobs that our educational system has left too many of our young unqualified to fill. George Gilder, that trenchant social critic, puts it bluntly:

> "As long as we teach more students sex education and cooking than physics and calculus, we *must* depend on immigration for key technical personnel. The alternative is a real decline in U.S. competitiveness."

Without endorsing the provocative Mr. Gilder, I can agree that a new seriousness about the business of education is what we must have. Vocational education is changing to meet the challenge.

Many worthy reforms are being advocated which deserve study. We have certainly moved away from traditional society of early school-leaving, apprenticeship or marriage, fixed roles and limited choices. But just as we reject a system which educates for only *one* role, we must reject alike a system which prepares for no role. Whether we talk about the young dropout who becomes one of the hard-core unemployed or about the directionless students in their late twenties who return to their parents homes in a phenomenon called "nesting," young people are being disserved by our education system if it does not provide them early on with an awareness of the necessity, the dignity, and the ethic of work.

To achieve a new seriousness in our approach to education, I have proposed a redefinition of vocational education focusing on a three dimensional model. The components of this model are process, methodology, and occupationally specific education.

The process of career development can help young people develop goals and make appropriate career and educational choices throughout the K-12 continuum. We can and should infuse such information and the values they imply--into each classroom setting.

The applied or experimental methodology of vocational education can help to support and enhance many of our traditionally academic course offerings. And vocational educators need to instill academic vigor in their curricula. The applied or experiential methods of vocational education helped to make us the world leader in agriculture and manufacturing. Now, they must do more.

Occupationally--specific education at the secondary level may become increasingly difficult to justify in a time of rapid technological change and budgetary constraints. We are witnessing already the process in which occupationally-specific education is deferred until the post-secondary level. This process will require a far greater articulation of effort among high schools and community colleges, vocational-technical institutes, and private schools. Further, there must be a concerted effort between education and business.

I believe the implementation of this three dimensional model for reform of vocational education will not only help combat school dropouts, it will greatly enhance our international competitiveness.

If information is the key to battling such old problems as teen pregnancy and such new ones as AIDS, it is also the key to preparing for meaningful work. The rapid drop in the cost of home computers may have a revolutionary impact on family, work, and education. One writer has called this phenomenon "the natural evolution of the democratization of information use begun more than 500 years ago by Gutenberg." Workers in a service economy may prefer to be "on-line" at 8:00 a.m. rather than on the freeway. The historic economic and population shifts which brought about the rise of industrial and commercial cities may yield to new realities: the ability of increasing numbers of people to combine home and work responsibilities.

We have recently seen numerous reports in the media and in government on the plight of the American family. But technological advances may lead to family re-empowerment through the use of home computers. Access to knowledge is access to power. Home computers linked to databases may give families the opportunity, for example, to reduce health care costs. A 1979 annual report of the U.S. Surgeon General points out that "increasing our life expectancy is largely a matter of how we use information." New programs may afford families the chance to enrich and enhance their childrens' classroom experiences or even, in some cases, substitute for it. Government, too, will find its actions subject to increasing scrutiny as citizen-activists gain access to voting records, administrative decisions, and--most interesingly--political contribution lists. While there are hopeful aspects to all of this change, we must be alert to the possibilities that our hoped-for ideal of the New England Town Meeting could degenerate into an anarchic ungovernable mass of jealous tribalisms. But there has always been risk associated with freedom. There was risk in allowing new states and frontier people to participate equally with the original states and their more educated citizens. I am confident that our constitutional system--which has worked for two hundred years--is capable of adjusting to new technological challenges.

Vocational education which prepares for the jobs of the future will identify and expand opportunities in the health occupations. Our office will sponsor demonstration programs for training biotechnicians. We need to be aware, though, that we are entering a field fraught with controversy. The use of hormones to stimulate plant and animal growth--while weighing health hazards--has been vigorously debated. As we move into new areas--such as patenting genetically engineered new life forms--we may expect the volume of disputes to increase. And, as the recently-decided Baby M case in New Jersey shows, when new technology is applied to issues of human reproduction, some of the most divisive and fundamental issues are raised.

I would not presume to suggest that wehave the answers to these dilemmas. But I do suggest that the technological choices we make can be informed by our ethical principles. A decision, for example, to pursue *in vitro fertilization* as a solution for the problems of infertility might incline us not to fully research the prospects for laser surgery to repair blocked fallopian tubes.

We are all familiar by now with the various spy scandals which have shocked the American people. Our national security is dependent in new ways on securing our communications. Ironically, the most sophisticated of systems--our nuclear submarines and the encrypted messages which give them their orders--were betrayed by the Walkers for the oldest of motives--greed. A system which places all reliance on technological sophistication and fails to consider human character is quite simply, doomed. We may not survive without the latest available technology for our defense system, but we certainly will not survive without inculcating a sense of loyalty and patriotism in our service men and women. And we cannot find such volunteers for our military and diplomatic posts, if our educational system does not provide them. In this respect, I would particularly commend vocational educators, vocational student organizations, and vocational graduates. The stress they have historically placed on such traditional values as patriotism, citizenship, and respect for our American tradition of religious liberty are an example to be followed by all educators. No society can safely pursue technical competence without simultaneously trying to instill the highest moral and ethical standards.

Technological literacy will not only be important to us as a commercial nation, it will be central to the vitality of our democratic institutions. The current debate over the President's Strategic Defense Initiative is a prime example. SDI has been derided by its opponents as a "Star Wars" system. The distance to the nearest star is six light years; the distance to intercept incoming missiles is mere thousands of miles. That discrepancy might be a comment on the technological literacy of SDI's opponents, although I don't think scientific precision of expression is what they're aiming at. We will need to engage the scientific, technical, and defense communities in a serious discussion of alternatives which must then be weighed by the American public and their elected officials. It may be that we decide not to develop and deploy the SDI. But I would hate to think that this decision was based on the public's preference for the anti-missile defense system we currently have. A recent poll showed that over 60% of the American people are simply *not aware* that the United States has *no* defense against nuclear missiles. No defense against missiles launched by Gorbachev or by Kaddafi or by Khomeini. None.

The Strategic Defense Initiative encompasses one project which has been code-named *Prometheus.* It is named after the mythological character who displeased the Greek Gods by giving man the knowledge of fire. The project is well-named. As great English biologist J. B. S. Haldane has written: "The chemical or physical inventor is always a Prometheus. There is no great invention, from fire to flying, that has not been ahiled as an insult to some God."

Against this promethean impulse has always ranged the spirit of the Luddites. These English craftsmen, early in the 19th century, rioted and wrecked the machines they feared would put them out of work. In the same cramped, crabbed logic, opinion-leaders and self-styled moralists complain of putting defensive weapons in space, fearing technology, and showing more compassion for E.T. than for defenseless children here on earth.

Educators must equip students to follow the technical arguments for or against the Strategic Defense Initiative. We cannot make informed choices as citizens and voters without knowledge. As Thomas Jefferson said: "If a nation expects to be ignorant and free. . .it expects what never was and never will be".

SDI is more than a technical system: it is a concept and a commitment. In a similar fashion, space scientists like Werner von Braun supported the concept of landing a man on the moon by the end of the 1960's. There was, of course, considerable debate then within the scientific community about the feasibility and the advisability of such a venture. But John F. Kennedy made the commitment.

Any one who recalls those historic years of the space race will remember the fears that were raised: What is mens' hearts could not withstand prolonged weightlessness? What about the Van Allen radiation belt? What if the lunar lander sank in hundreds of feet of powdery moon dust? What if unknown microbes brought back a deadly contagion to a defenseless earth? Each of these scientific problems was either dismissed or compensated for. The important thing was the firm commitment or the President and people of the United States.

We do not have the luxury of deciding on SDI in the calm atmosphere of a visionary Camelot. We must decide the issue in the full glare of media attention. I have no argument with tough professional journalists who ask tough, professional questions. But here's a probing questions for SDI's critics: The world's leading experts on the capacity of Soviet ballistic missiles must be the Soviet leaders themselves;

If our SDI would be so ineffective against their offensive weapons, why are *they* so desperate to have us scuttle the program?

Recently, a presidential candidate said the U.S. and the Soviet Union were about to enter an arms race--and the Japanese would win. It was a clever way to make people aware that excessive concentration on weapons systems could lead to commercial defeat. One answer to that candidate's charge can be found at the National Bureau of Standards. There, the "factory of the future" has been designed and produced.

It "addresses issues of standardized interfaces for the flexibly-automated, robotics-based, computer-integrated factory of the future. This public facility is open to all. The discussion of the commercial and industrial application of LASER technology is open to all--including the Japanese and, through our publications, the Soviets. So, the commercial competition between two free societies like Japan and the United States could well lead to discoveries in LASER technology which have direct military applicability.

It may be argued, therefore, that the technology for a space-based missile defense system will be developed as a "spin-off" of commercial competition. The only policy choice which may be open to us is whether we wish to join the Soviets in deploying such a system.

George Gilder provides a ready answer for those who fear Japanese advances in electronics: "The key ingredients in electronics are not machinery or materials, but ideas and inventions. To imagine the Japanese will dominate the age of information because they have the purest silicon and industrial gases is like predicting the Canadians will dominate world literature because they have the tallest trees."

I share Gilder's commitment to intellectual freedom. In the Age of Information, it gives America a greater advantage over any other commercial or military rival than firepower or buying power. When Samuel Slater came to America to build our first cotton mill in 1793, he bought the plans *in his head*. The Crown had decreed no technology could be taken out of Britain.

We were a beacon drawing talent and ideas then. We were a beacon for Albert Einstein in the dark days of the Third Reich. We are such a beacon for creative and scientific achievement today. Those who build walls to keep in their best minds must do more than preach GLASNOST--openness--to the people of the United States: they must practice it.

We are basically a nation of Prometheans--optimistic about the future and the ability of technology to solve our problems and provide us with a better life. It is our responsibility as educators--through technical education and technological literacy, combined with the highest sense of moral and ethical standards--to insure that the flame of optimism continues to burn brightly.

Sociotechnical Literacy: An Alternative to the Technological Perspective

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Introduction

The technological revolution, and the ways it is changing the American workplace, have been addressed frequently in the popular media and in professional literature. Nevertheless, there is considerable uncertainty and disagreement about the nature of technological development, its impact on skill requirements, and its impact on the education and training needs of workers.

On the other hand, many, including the Joint Economic Committee of the U.S. Congress (1980) and the National Commission on Excellence in Education (1983), have concluded that technological change is resulting in an increased demand for higher levels of skills and better educated workers. Thus, for example, the National Commission (1983) asserts that:

> The demand for highly skilled workers in new fields is accelerating rapidly . . . Technology is radically transforming a host of other occupations . . . Analysts examining these indicators of student performance and the demands for new skills have made some chilling observations. Educational researcher Paul Hurd concluded . . .'we are raising a new generation of Americans that is scientifically and technologically illiterate.' . . John Slaughter, a former Director of the National Science Foundation, warned of 'a growing chasm between a small scientific and technological elite and a citizenry, ill-informed, indeed uninformed, on issues with a science component.' (p. 10)

In spite of these concerns, little direct attention until recently has been given to the study of technology and technological change in the high school curriculum. What little attention has been given has usually been in the form of beefed-up courses in science and mathematics, or instruction in computer literacy. These responses, I point out, while useful, do not address directly the study of technology as an important subject in its own right.

On the other hand, there are those who argue that the impact of new, high technology on the workplace is minimal and that most jobs now and in the future will require less skill rather than more (Levin & Rumberger, 1983; Rumberger & Levin, 1984). They conclude that:

> . . .the expansion of the lowest skilled jobs in the American economy will vastly outstrip the growth of high technology ones; and the proliferation of high technology industries and their products is far more likely to reduce the skill requirements of jobs in the U.S. economy than to upgrade them. (Levin & Rumberger, 1983, p. 2)

Levin and Rumberger (1986) point out, however, that the service sector has generated a major share of new jobs over the last two decades and is expected to generate the major share of new jobs in the next decade. Levin and Rumberger go on to note that:

> As a whole, workers in the service sector have higher levels of education than workers in the industry sector. Therefore, the continued growth of the service sector will have a tendency to raise the educational requirements of work in the U.S. economy independently of any upgrading of requirements that might take place within occupations. (p. 11)

This introduction has attempted to point out two things; first, that the educational consequences of technological change are far from being clear and certain, and second, that other factors and forces in society and at work appear to be at least as profound in their potential consequences for both work and schooling as technological change.

The thesis presented here is that the broader perspective and goal of what will be referred to as *sociotechnical* literacy is more consistent with major workplace innovations and emerging social/ demographic and economic/technological developments than a purely technological focus (Carnoy, Shearer & Rumberger, 1983; Ferguson, 1980; Naisbitt, 1982; Work in America Institute, 1982). In contrast to the more popular notion of technological literacy, sociotechnical literacy seeks a balanced treatment of the human social and demographic aspects of work, as well as the economic and technological aspects, and focuses on their interactions. It emphasized development of a broad perspective and understanding of the nature of technology and work in a democratic, technologically advanced society. It also emphasizes development of broadly applicable, highly transferable skills and knowledge needed to function effectively in such a society and workplace including development of: (1) group problem solving skills (e.g. interpersonal and group process skills, problem solving and decision making, planning, and communication), (2) skills in business economics, business operation, and statistical quality control, and (3) an understanding of the philosophical underpinnings and consequences of the shifts from a mechanistic, technological, scientific management perspective of work to a high-involvement, participative management perspective (Pratzner, 1984a; Pratzner & Russell, 1984b).

To lay the groundwork for this discussion of sociotechnical literacy, we will first examine what is referred to as quality of work life (QWL) developments in the workplace. Next, we will discuss briefly some of the social, demographic, and economic developments that support quality of work life developments. Finally, we will suggest how sociotechnical studies grow out of quality of work life developments and support effective preparation for work.

Quality of Worklife: An Overview

Quality of work life activities are ways of structuring jobs and organizing work that typically have the dual focus of (1) improving the economic viability of an organization, and (2) making work a more satisfying and rewarding experience for workers and managers. As Goodman (1979) points out, "The focus is not on improving either the productivity dimensions or the psychological outcomes of work, but rather on jointly improving both of these outcomes" (p. 8). Goodman further notes that QWL activities usually attempt to "restructure multiple aspects of an organization simultaneously, such as the authority, decision making, reward, and communication systems, rather than any one dimension." The purpose of these multidimensional changes is generally "to provide greater democratization of the workplace, greater control for the worker over his or her environment, and greater joint problem-solving between labor and management" (Goodman, p. 8).

The changes occurring in work and referred to here as "quality of work life developments" appear in workplaces in many guises--"high-involvement, participative management," "workplace democracy," "humanization of work," "democratic sociotechnical design of work." Some of these terms may carry special meanings and connotations for the specialists and professionals who use them, and there is little apparent agreement among these specialists on a common set of definitions. Nevertheless, their underlying principles and techniques do not appear to be very different; they all focus on improving human well-being and organizational effectiveness.

Nadler and Lawler (1983) trace the historical development of the QWL movement and its evolving definitions, and provide a concise working definition:

> Quality of work life is a way of thinking about people, work, and organizations. Its distinctive elements are (1) a concern about the impact of work on people as well as on organizational effectiveness, and (2) the idea of participation in organizational problem solving and decision making. (p. 26)

Mills (1978), former director of the American Center for the Quality of Work Life, has defined QWL as:

> A way to provide people at work (managers, supervisors, rank and file workers) with structured opportunities to become actively involved in a new interpersonal process of problem solving toward a better way of working and a more effective work organization, the payoff from which includes the best interests of employees and employers in equal measure. (p. 23)

The most important aspect of the QWL approach is the establishment of new cooperative diagnostic and problem solving bodies with, as Mills stresses, "the authority to make things happen" (Mills, 1978, p. 35). Such bodies are called by a variety of names--quality circles, QWL committees, problem solving task forces. What is important about them is their purpose and underlying rationale.

As Mills points out, these bodies or structures provide "the opportunity for people to seek together to identify barriers to the effectiveness of their work organization, or their part of it, and through problem solving, tumble these barriers down" (Mills, p. 35). They are based on the conviction, by all involved, that "there's a wealth of largely untapped creative expertise and insight in the organization which the old, rigid, stable structure and organization charts have kept hidden" (Mills, p. 35). These problem solving and decision making bodies are organized ways of channeling that latent expertise and putting it to work in the interest of the workers and the organization.

The New York Stock Exchange (1982) estimates that, by the early 1980s, about 13 million workers were currently included in a variety of QWL and productivity improvement programs (p. 23). The Exchange has collected survey data showing that the most rapidly growing programs have been quality circles, restructuring plant and office space, job redesign, task forces, group incentive plans, and production teams (p. 26).

Among the reasons that corporations initiate QWL programs are to cut costs, to improve poor employee attitudes and morale, to improve productivity and product quality, and to reduce worker turnover. Other reasons include positive reports from other corporations and a change in management philosophy. Some management and union advocates of QWL emphasize improvement of quality of work life as a goal in itself to be sought as long as productivity is not adversely affected. But many specialists agree with Walton (1979) that "projects with productivity and QWL as goals are more likely to succeed on both counts than projects that stress one goal to the exclusion of the other" (p. 88).

More than half of all corporations surveyed by the Exchange considered their programs successful or highly successful. A large majority thought that participative management techniques represented a promising new approach rather than a passing fad.

Ideological and Practical Support for Quality of Work Life Developments

Ideological Support

Many social and political scientists believe the nation is now in the midst of a major social revolution--a nonviolent one aimed at reaffirmation of the democratic experiment the founding fathers began a little over two hundred years ago. They see the nation striving toward a higher quality of life through fuller implementation of the ideology and practice of democracy--democratization not only of our political institutions, but also of our social institutions, our families, offices, and factories.

Ferguson (1980) sees the shift to greater democratization as a distinctly new way of understanding and explaining reality and of thinking about old problems: "Roles, relationships, institutions, and old ideas are being reexamined, reformulated, redesigned. We have begun to image the possible society" (p. 29). This new view promotes the autonomous individual in a decentralized society.

In their recent book, *A New Social Contract*, Carnoy, Shearer, and Rumberger (1983) contend that the assumption that the economic system in the United States is self-governing is "palpably false" and that "an alternative must integrate economics and politics on a new basis--a democratic, participative governance of polity and economy" (p. 2). They call this alternative "economic democracy" and think it will work because "it is rooted in the basic American ideals of participation, fairness and efficiency" (p. 4).

Carnoy et al. further state that the cornerstones of economic democracy "are direct and individual public accountability for investment policy and increased worker and consumer control of production--what and how things are produced" (p. 3). They argue that greater, not less democratic participation is required "at the community level, at the plant level, at the level of national economic policy" (p. 3). In addition:

> Greater democracy means that those with jobs will have much more to say about the way those jobs are organized; those who live in communities will have more to say about what happens to those communities. . .consumers will have more to say about the products they buy and the kinds of long-run investments the economy should make; senior citizens will have more to say about their activities and health care; students will participate more in their education; and all citizens can decide together whether the human race should be destroyed by nuclear war or survive in a saner world. (Carnoy, et al., p. 2)

As Naisbitt (1982) sees it, one of the ten "megatrends" shaping our lives is the shift from representative democracy to participative democracy. According to him, the guiding principle of participatory democracy is that people must be part of the process of arriving at decisions that affect their lives. His wide ranging examples and analyses provide convincing arguments that:

> The ethic of participation is spreading bottom up across America and radically altering

> the way we think people in institutions should be governed. Citizens, workers, and consumers are demanding and getting a greater voice in government, business and the marketplace. (p. 159)

Most Americans today expect workplaces to be compatible with a free and open political system. "The spirit of our age. . .is characterized by fluid organizations reluctant to create hierarchical structures, averse to dogma" (Ferguson, 1980, p. 18). A report of the Work in America Institute (1982) points out that:

> There has been a marked and persistent shift in the attitudes of younger workers, which is now spreading to the work force as a whole. The work ethic-a basic belief in the value of work--has not diminished, but many workers feel that there is an incongruity between more flexible modes of life and expression in the outside community and the authoritative, technocratically controlled workplace. They do not oppose the legitimate exercise of authority, but they do resent 'authoritarianism,' a distinction that is crucial to worker-manager relations and national productivity.

Since Americans live in a free and open political system, they expect conditions in the workplace to be compatible with the society. Their proper expectations include the right to free speech, privacy, dissent, fair and equitable treatment, and due process in work-related activities.

A majority of all Americans today believe that they have a right to take part in decisions affecting their jobs (pp. 3-4).

Mills (1978) reminds us that most of the old authoritarian values that underlie the current paradigm of work originated at the turn of the century. He notes that Frederick Taylor, often referred to as the father of current "scientific management," urged:

> Dividing human and machine labor down into the smallest and easiest functions: to create dumb, foolproof jobs for dumb human beings, whom we characterized as essentially lazy, greedy, and demanding of discipline. (p. 25)

Among the reasons why scientific management may have been so popular, supported, and perpetuated throughout American industry was the reality that, at the turn of the century, the majority of unskilled and semiskilled workers were immigrants to the United States and could speak little or no English. Rebecca Smith, senior personnel representative in the manufacturing productivity division of Hewlett Packard, notes that the racism and classism that prevailed during this period enabled managers to ignore the issue of equity in the workplace. Managers did not know and did not learn the workers' languages, and, under these conditions, their most efficient method of maintaining a production facility was to reduce jobs to the minute, mechanistic performance of simple, independent tasks. As Trist (1981) points out, "in a technocratic bureaucracy, the parts are broken down so that the ultimate elements are as simple and inexpensive as possible, as with the unskilled worker in a narrow job who is cheap to replace and who takes little time to train" (p. 38).

The current paradigm of work, which often results in workers being treated as unthinking and uncaring parts of the production process, may have been a rational paradigm early in the century, but it was then and is now incompatible with our democratic ideals regarding the worth and welfare of individuals. One worker, quoted in a *Los Angeles Times* article on 23 October, 1980, put it this way:

> I'm a somebody in my community. I'm on the board of the PTA. My children treat me with respect. I've even got my own banker who knows my name. But when I get to the job, I'm treated like one of my children.

It is a mistake to think of QWL developments as a passing fad or merely as a collection of gimmicks designed to make workers happier. Rather, the QWL paradigm reflects an alternative philosophy and approach to the management and organization of work, one that is compatible with and supported by a broader societal shift to greater democratization of all of our institutions.

Practical Considerations

As long as American factories and offices were operating relatively efficiently--as they were throughout most of the 1960s and into the early 1970s, when the quality of work life movement was in an early stage of development--there were few compelling incentives to align work practices more closely with democratic ideals. "If it isn't broken, don't fix it" was the rule of the day.

In this "business as usual" environment, the early quality of work life activities aimed primarily at improving worker morale and satisfaction and gave relatively little direct attention to productivity-related concerns. As a result, successes were few and far between. Many early advocates and developers overpromised on the benefits of QWL activities, and their ideological motives and objectives did not persuade hard-nosed business executives worried primarily about short-term improvements in the "bottom line." That began to change around 1970, however, when, as Reich (1983) points out, the scientific management era came under serious question in America.

Beginning in the 1970s, the productivity growth rate in the United States began to approach zero. Since then, it has remained low and has even been negative (U.S. Department of Labor, 1981). By the late 1970s and early 1980s, the set of problems related to this lack of productivity growth--slow economic development, high unemployment, high inflation, lower quality and higher prices for goods and services, and the loss of competitive positions in domestic and international markets--reached crisis proportions (Congressional Budget Office, 1981; Huddleston, 1982).

The changing structure of American industry

Among the root causes of these problems is the fact that America has become part of an increasingly complex and competitive global economy. "By 1980, more than 70 percent of all the goods produced in the United States were actively competing with foreign-made goods" (Reich, 1983, p. 44). But as Reich points out, "American producers have not fared well in this new contest" (p. 44). Reich's figures indicate that

> since 1963, America's shre of the world market has declined in a number of important areas: automobiles, by almost one-third; industrial machinery, by 33 percent; agricultural machinery, by 40 percent; telecommunications machinery, by 50 percent; metalwork machinery, by 55 percent. (p. 45)

Reich argues that, whatever the final product, "those parts of its production requiring high-volume machinery and unsophisticated workers can be accomplished more cheaply in developing nations" (p. 45). Skilled labor, according to Reich, is the only dimension of production where we can retain an advantage over developing nations. "Technological innovations can be bought or imitated by anyone. High-volume, standardized-production facilities can be established anywhere. But production processes that depend on skilled labor must stay where the skilled labor is" (p. 47).

"Flexible-system production" is seen by Reich as the reverse of high-volume, standardized production and as the way for America to gain competitive advantage in the global economy.

> Flexible-system production is characterized by technological innovation, precision manufacturing, and customization of products. It demands a new style of management, emphasizing teamwork instead of hierarchy and problem-solving instead of routinization. . .Flexible-system production is rooted in discovering and solving new problems; high-volume, standardized production basically involves routinizing the solutions to old problems. . .Flexible-system production requires an organization designed for change and adaptability. . .a new productive organization, requiring a different, less rigidly delineated relationship between management and labor. . .no set of 'standard operating procedures' locks in routines or compartmentalizes job responsibilities. . .The work requires high-level skills precisely because the problems and opportunities cannot be anticipated. . .the radical distinctions heretofore drawn between those who plan work and those who execute it is inappropriate. . .There is no hierarchy to problem-solving: solutions may come from anyone, anywhere. . .nearly everyone in the production process is responsible for recognizing problems and finding solutions. . .When production is inherently non-routine, problem-solving requires close working relationships among people at all stages in the process. . .In flexible-system production much of the training of necessity occurs on the job, both because the precise skills to be learned cannot be anticipated and communicated in advance and because the individual's skills are typically integrated into a group whose collective capacity becomes something more than the simple sum of its member's skills. . .Their sense of membership in the enterprise is stronger and more immediate than any abstract identification with their profession or occupational group. They move from one speciality to another, but they remain within a single organization. (pp. 47-50)

Trist (1981) notes many distinctions and concerns similar to those pointed out by Reich. He feels that traditional technocratic bureaucracies are mismatched with what he calls "new turbulent environments," in which higher levels of interdependence among organizations and higher levels of complexity together generate much higher levels of uncertainty (p. 39). Trist argues that, in this new environment, "large competing organizations, all acting independently in diverse directions, produce unanticipated and dissonant consequences" (p. 39). Furthermore:

> The higher levels of interdependence, complexity, and uncertainty now to be found in the world environment pass the limits within which technocratic bureaucracies were designed to cope. Given its solely independent purposes, its primarily competitive relations, its mechanistic authoritarian control structure and its tendency to debase human resources, this organizational form cannot absorb environmental turbulence, far less reduce it. (p. 40)

Like Reich, Trist concludes that, "a transformation of our traditional technocratic bureaucracies into continuous adaptive learning systems is imperative for survival and involves nothing less than the working out of a new organizational philosophy" (p. 44).

The QWL movement responds to productivity-related problems and supports the transformation called for by such writers as Trist and Reich to a more participative philosophy and approach to the organization and management of work. As noted by the New York Stock Exchange study (1982):

> The role that people play matters greatly. . .Compared with the capital side of boosting productivity, the investment of time and money in better utilizing peole is relatively small; the potential benefits are enormous. (p. 3)

According to Reich (1983):

> Financial-capital formation is becoming a less important determinant of a nation's well-being than human-capital formation. . .Only people can recognize and solve novel problems. Machines can merely repeat solutions already programmed within them. (p. 66)

He concludes, as does Birch (1981), that "industries of the future will depend not on physical 'hardware,' which can be duplicated anywhere, but on human 'software,' which can retain a technological edge" (Reich, 1983, p. 66).

The changing work force

Both demographic and attitudinal changes in the work force support the continued development of QWL activities. For example, the rate of increase in the total size of the labor force will decline throughout the 1980s. On the average, it is estimated that there will be three-quarters of a million fewer persons added to the labor force each year during the 1980s (Institute for the Future, 1979). The days of abundant cheap labor are coming to an end. With fewer new workers coming into the labor force, employers will have greater incentives not only to invest in labor-saving technology, but also be flexible in meeting the needs of employees in order to attract and hold a stable workforce.

As the "baby-boom" cohort matures, the "new" youth--those born since 1970--compose a smaller portion of the overall population (Lewis & Russell, 1980). The consequences of fewer youth is a dwindling supply of entry-level workers and fewer people for jobs in the secondary labor market. At the same time, the percentage of minority youth will grow, so that, "by the early 1990s, minorities will account for more than 30 percent of the population in the entry-level age groups (16 to 24 years old)" (Lewis & Russell, 1980). These shortages of qualified applicants may force employers to change traditional work structures appreciably in order to attract and retain the labor needed. They may also become motivated to see that the traditionally poor achievers in school--the disadvantaged, non-English speaking, and so on--receive help to become competent in basic skills and become otherwise better prepared to work.

American women have returned to paid employment in proportions not seen since statistics have been kept. Estimates are that by 1995, 44 percent of all workers will be women (Lewis & Russell, 1980). Furthermore, women increasingly demand to receive equal pay for equal work and to be considered seriously for work in all types of jobs for which they are appropriately qualified.

Many more women are single parents supporting a household, others are members of two wage earner families. Both of these situations create a demand for change in the workplace. Working mothers need flexibility for doctor's appointments and day care, for example. Both male and female workers in two wage earner families may desire longer vacations in lieu of other benefits or higher pay. Women who previously left the work force and who returned to work looking for fulfillment also have different expectations. Women want challenging jobs that are meaningful. They wish to use their skills and to have an impact on the economy and society.

Young workers--those born between 1945 and 1965--are highly educated and accustomed to the benefits of life during the affluent 1950s, 1960s, and 1970s. They graduated from high school and attended college in record numbers. The median years of schooling completed for those over age twenty-five has grown from 8.6 years in 1940 to 12.5 years in 1979, and the proportion of those with four or more years of college has almost quadrupled in the same time period.

Partially because of their quality education, these young workers have high expectations concerning what they expect from work (*Business Week*, 1981; Levitan & Johnson, 1982; O'Toole, 1973). Their whole pattern of earning money and their thoughts about security do not center around the Great Depression of the 1930s, as is the case of many workers now reaching retirement age. Many of these young workers want their work to be interesting and significant (Cooper et al., 1979; Staines & Quinn, 1979).

At the same time, periodic surveys have shown a statistically significant decrease in workers' perceptions of job satisfaction. For example, in 1967, 27 percent of workers interviewed felt they had skills that were not being fully utilized; by 1977, this percentage had risen to 36 percent (Institute for the Future, 1979). Current surveys of young people show that non-monetary rewards (i.e. interesting work, seeing the results of your work, having a chance to develop skills, participating in decisions) are becoming more important (Cooper et al., 1979; Staines & Quinn, 1979).

The research on whether the average worker is now more or less satisfied with work than in the past contains much controversy:

> Some commentators argue with vigor that we are currently in the midst of a major 'work ethic crisis' that portends revolutionary changes in how work will be designed and managed in the future. Others respond that the purported 'crisis' is much more in the minds of those who herald its arrival than in the hearts of those who perform the productive work of society. (Hackman & Oldham, 1980, p. 5)

Levitan and Johnson (1982), for example point out that "the work ethic has always existed more in the world of scholars than of laborers, more as a concept than as a powerful motivating force keeping people at work" (p. 28). They conclude, therefore, that "the survival of work does not depend on the motivational force of an abstract work ethic" (p. 28).

Many workers want more than just a good paycheck; they also want "to become masters of their immediate environments and to feel that their work and they themselves and to feel that their work and they themselves are important--the twin ingredients of self-esteem" (O'Toole, 1973). However, people who do not become masters of their work environment make adjustments to avoid feeling continuous dissatisfaction and distress. Those adjustments may range from working a little less hard or taking an unnecessary sick day, to sabotage or theft of company property (Hackman & Oldham, 1980). Dissatisfied workers who make these adjustments may even say they are content with their job, because they have come to define "satisfaction" as minimal work for a paycheck that supports them.

In general, the decline in labor force growth, the search for self-fulfillment, increased levels of educational attainment, increased numbers of two wage earners in a household with fewer children, the move toward more permanent part-time work, and the increased competition for fewer middle management positions by the increasing numbers of people from the "baby boom" cohort all signal the need for greater employee flexibility in dealing with job dissatisfaction. At the same time, they provide powerful incentives for employers to be flexible in meeting the personal needs of workers and managers. Marshall (1982) suggests that, although the demand for worker participation has not reached the intensity in the United States that it has in Europe and Japan, the desire for greater worker participation in other industrialized nations will undoubtedly intensify pressure here for some forms of work participation.

Quoting a 1979 article in the *Los Angeles Times* by Tom Hayden, a California Democratic candidate for United States Senate and a co-defendent with Jerry Rubin in the "Chicago Trial," Ferguson (1980) points out an aspect of the aging of the work force that is especially relevant and supportive of quality of work life developments. She reminds us that the youth of the 1960s--the so-called 1960s activists--are now into their middle years and many are well established in the labor market. Hayden's and Ferguson's point is this:

> The reappearance in years ahead of the '60s activists. . .will be misread by many.
>
> Some will not recognize us, and some will believe we have 'settled down' too much. We will not be a protesting fringe, because the fringe of yesterday is the mainstream of

> tomorrow. We will not be protesting but proposing solutions: an energy program emphasizing renewable resources. . .democratic restructuring of large corporations. . .technology to decentralize decision making and information sharing. . .. (p. 209)

Sociotechnical Studies

Let us turn now to a further consideration of sociotechnical literacy. As noted earlier, sociotechnical literacy grows out of quality of work life developments and supports effective preparation for work in a democratic, high-involvement workplace. In contrast to the specialized occupational skills and technological literacy emphasized today in vocational education, sociotechnical studies emphasize a balanced concern for the social human aspects of work, as well as the technological aspects, and an appreciation of their interactions.

Several years ago we began examining QWL developments in the American workplace*. (* Our full report--Praztner & Russell, 1984b--, including more detailed examples of skills and knowledge in the three skills areas noted above, is available at cost through the publications office of the National Center for Research in Vocational Education.) Our review of the extensive QWL literature, discussions with QWL experts, and interviews and observations at leading firms that have implemented substantial QWL activities suggest that to function effectively in high-involvement, participative work settings, workers and managers not only need good basic skills and technical skills, but they increasingly need improved skills and knowledge in the three areas of broadly applicable, highly transferable skills and knowledge including: (1) group problem solving skills, (2) skills in business economics, and (3) an understanding of the philosophical underpinnings and consequences of the shift to a high-involvement, participative approach to the organization and management of work.

Components of Sociotechnical Studies

Group problem-solving skills

Having workers and managers participate in problem-solving groups requires vastly different analytical skills than when workers are told what to do by management and are not expected to think--the current norm for many jobs. Many people in work settings, and many students, do not have the skills to work successfully in groups doing complex problem-solving (National Assessment of Educational Progress, 1982). Most people have not been trained in how to solve problems in groups. To throw people together in a room and tell them "to solve problems" or "make decisions" and expect them to produce meaningful results is wholly unreasonable (Nadler & Lawler, 1983).

While group problem-solving skills have long been recognized as important for management staff, they are of growing importance to all levels of employees in high-involvement companies as a means for change and improvement in quality, costs, and employee morale. The old belief that "two heads are better than one" has been confirmed with evidence that cooperative approaches to work are more effective than competitive approaches (Johnson et al., 1981). This means that all employees will need to work together more to diagnose problems and implement effective solutions.

Group problem-solving includes such skills as : (1) interpersonal and group process skills, (2) communication skills, and (3) thinking and reasoning skills. These are all complex, non-job-specific skills needed for effective participation in groups that focus on problem identification and solution. And they are not specific to particular firms or work settings. Rather, they are broadly applicable skills transferable to and useful in a wide range of work settings.

Additionally, in a QWL climate, a kind of learning ability is needed in which the learner has a capacity to create order and meaning out of his or her world. This is different from an emphasis on merely being able to acquire correct information. It seems to include the ability to deal with ambiguity and uncertainty, to deal with and "manage" differences (e.g. in people, values, technologies), and to visualize and make informed judgments about multiple outcomes and realities (i.e. not a linear, "binary," right-wrong approach to judgments and decisions).

Organizational and management skills.

Where workers and managers are to help improve the economic viability of their organizations, they need skills and knowledge of business economics and organizational management, which most employees do not have. Most people outside of schools of business and management administration have not been trained in how complex organizations are managed and operated. They therefore do not fully appreciate how their personal efforts may contribute to or diminish the effectiveness, efficiency, and quality of the products or services of their particular work organization.

Traditional skills taught to managers or learned by experience now must be shared with all levels of employees. Management texts for years have discussed business economics, operations, human resource management, and statistical quality control. These subjects must be taught to all levels of workers for high-involvement companies to function effectively.

A knowledge of the costs required to run a business, a typical profit margin, the effect of waste and downtime, the expense of benefits, and, the relationship between expenditures and income are crucial for thoughtful involvement in increasing company profit and reducing costs. Employees who do not understand the connections between the price of the product their firm markets and the wages and benefits that they receive or the amount of scrap at the end of the day cannot be expected to be very helpful in a program to provide a better product at less cost.

Just as workers and managers in high-involvement companies need to know about the financial workings of firms, they also need to know how the business operates functionally. This need stems from the basic issue of understanding how all of the individuals and departments are necessary and interlocking components. Employees who know how their efforts fit into the larger scheme are more likely to take pride in and assign meaning to their work. Understanding the coordination of resources, systems, and the relationships between the functions in their company encourages all staff to act as a whole, helps to reduce duplication of effort, and encourages the corrective feedback and information flow between functions--all of which save money, enhance quality, and make work more satisfying.

When all employees are involved in management-type tasks, they need to know what managers need to know: management theory; relationships between performance and other factors; models of communication; and human resource development. They may also need information about such issues as power, control, authority, delegation, job analysis, change processes, feedback, and appraisal.

Knowledge and skills in these areas are necessary to plan, organize, implement, and control work and to achieve its purpose. When all employees are involved at all four of these stages, then all are practicing managers and are theoretically a part of the management team.

One of the major types of changes in work design is the shift of responsibility for quality from an "end of the line" inspector back to each work unit and each worker. This means that both inspection skills and knowledge of statistical quality control are required. Inspection skills may vary according to the product. Statistical quality control techniques, however, are applicable across many settings.

Statistical quality control involves an understanding of standards and control limits for quality, sampling, measurement and data collection, and the development of control charts. These tasks require basic mathematical skills (e.g. calculating percentages, plotting graphs and charts) and introductory statistics (e.g. computing means and standard deviations).

Quality of work life skills.

If workers and students are to understand the importance of the skills and knowledge mentioned here, they need to understand the shift in the philosophy of work from a scientific management, technological work design to a democratic, sociotechnical philosophy. This should include an awareness of the historical shift in America from the earlier Tayloristic philosophy of work to the philosophy and values that are emerging in the QWL movement and in sociotechnical approaches to work. It should also include awareness of the roles that organized labor has played and its contributions to the evolution of QWL activities. It may also include an understanding of the shift to "open systems" and "ecological" perspectives of work, in which the welfare of systems is seen in terms of the quality of the interconnections of the parts, as opposed to an earlier, more atomistic and mechanistic world view (Wirth, 1983b). Students should also appreciate the critical distinction between the philosophy, values, and models of QWL developments, and the methods and techniques by which these values and beliefs are implemented in the workplace (e.g. quality circles, autonomous work groups, gainsharing plans, labor-management collaborations, and so forth).

Teaching Sociotechnical Studies

This brief overview of the major skills components of sociotechnical studies should have emphasized several points. First, sociotechnical studies focus on development of generally applicable, highly transferable skills and knowledge needed to function effectively in life and work. Second, sociotechnical studies emphasize development of a broad perspective and understanding of the nature of work in a democratic society.

With this discussion of the content of sociotechnical studies as a background, let us know turn briefly to a consideration of several key characteristics and concerns of programs or approaches for teaching sociotechnical studies.

Infusion.

Development of the component skills and knowledge of sociotechnical literacy is not typically included or emphasized in high school academic *or* vocational education programs. In vocational programs, their development rarely receives the amount of emphasis, relative to specific job skills, that their increasing importance in business and industry would seem to warrant.

Development of these skills does not fall conveniently into any one program or service area of the school. It is a total school responsibility, not just the concern of the elementary school or of a single discipline area within the school. The risk here is that the combination of the broader definition and derivation of these skills with the compartmentalization and disciplinary base of education--especially secondary-level education--could easily mean that the development of these skills is not seen as anyone's explicit responsibility. Thus, there is a pressing need at the elementary and secondary schools levels to: (1) identify better the specific skills that various school programs and levels are attempting to develop, (2) uncover commonalities among programs and levels, i.e. look for the things they have in common, not their differences, and (3) develop improved policies and approaches to better ensure development of critical skills.

This is *not* to say that development of these skills is the *sole* responsibility of vocational education, or that vocational education totally ignores such skills. Curriculum guides and instructional materials are available for some of these skill areas (e.g. problem-solving and communication skills). Development of other component skills of sociotechnical literacy are frequently the focus of such experiences and programs as Junior Achievement (e.g. business economics and organizational management) and of vocational student clubs such as the Vocational Industrial Clubs of American (VICA), the Distributive Education Clubs of America (DECA), and the Future Farmers of America (FFA) (e.g. group process and interpersonal skills). Nevertheless, these programs and materials are scattered and are usually peripheral to or ancillary aspects of the formal school curricula; seldom are they integrated into and emphasized in regular vocational programs.

One immediate and practical way to begin to develop sociotechnical skills is through the deliberate and planned *infusion* of these skills into existing practical arts and vocational education courses. Sociotechnical skills can be infused or integrated into ongoing classroom and laboratory experiences without eliminating what is presently being taught and substituting new things. Instead, a particular activity, project, or task used to accomplish some specific purpose or objective can be used, at the same time, to accomplish additional goals or purposes. Thus, the development of sociotechnical skills can complement the teaching of specialized occupational knowledge and skills.

To incorporate sociotechnical skills effectively within existing programs and settings, educators must be willing to rethink and reconceptualize what is presently being taught--how and why it's being done--and to refocus on instructional objectives, teaching strategies, and student learning activities in order to make a deliberate and careful identification of explicit opportunities to introduce or to practice and develop those broadly applicable, nontechnical skills. Students should be provided with as wide a range of opportunities as possible to apply these skills. The more opportunities given to students to practice them and the more realistic the opportunities are, the more likely that teaching will be effective.

While vocational and practical arts education have a shared responsibility with other school programs to contribute to the development of these skills, they are unique among educational programs in their potential for so doing. This is because they provide unparalleled opportunities for hands-on approaches and for extensive application and practice. Unfortunately, this potential can be easily overlooked in the day-to-day routine of teaching and learning.

Application.

Another critically important concept in any approach for teaching sociotechnical skills is that of the application of skills and knowledge.

If it is correct that major trends and reforms in education re-emerge every ten to twelve years in cycles, then it is almost certain that within the next decade the outcry for reform will center on the need for "useful" skills and knowledge. The public, and especially employers, will be upset and lament the fact, that although kids leaving school are bright and they seem to know a lot of things, they cannot *do* anything. The cry will be--why cannot the schools give us students who can apply their knowledge and skills to real world, everyday needs and uses.

Clearly, today's obsession with students acquiring abstract skills to become what Arthur Wirth has described as a generation of "test-takers and right-answer-givers" is too narrow a purpose for public education. We need a broad purpose and innovative programs to help all students learn how the increasingly abstract knowledge and skills they are acquiring in academic classrooms can be *integrated* and put to *practical use* in the real world. The need is for the meaningful integration of skills and their practical applications and uses.

Vocational education can and must play a key role in meeting this need. Vocational education must be both a "process" and a "program." It must aim at reinforcing development of basic and higher-order skills and at developing the application and use of skills in practical settings for practical purposes.

The high-order skills and knowledge increasingly required by work in technologically advanced and participative workplaces fall within the five new basics outlined by the National Commission on Excellence (1983). As emphasized by the National Commission, their development requires "application" and practice. For example, such skills as working effectively in groups, problem solving, and decision making are not developed effectively in the abstract through lecture, discussion, drill, or rote learning (the factory model of education). They are best learned through realistic hands-on experiences and practical application, which is the kind of teaching and learning that has characterized vocational education since its introduction into the public schools. Thus, vocational education is in a unique position to enhance quality and excellence in education through its instructional approach.

Thus, it seems highly desirable that schools provide learners with opportunities to practice the application and use of skills and knowledge under as wide a variety of conditions and circumstances as possible so that the potential for transfer and wider use of those skills in various and novel situations is increased. It also seems desirable as well to inform learners that skills developed to levels of mastery potentially are broadly applicable skills. Learners should then be provided with a range of examples or instances in which the skills they are developing could be applied. In so doing, they should be informed of the skills they have acquired and their level of proficiency in those skills; they should also be informed of skills not acquired or not developed to higher levels of proficiency that represent remaining developmental needs. These remaining needs can serve as personal objectives for the continuous learning of the individual.

Cooperation.

A great many of the work innovations and quality of work life developments we have discussed hinge on greater cooperation and involvement of workers both in management and production (Pratzner & Russell, 1984a). Further, we know that for a wide range of school subjects and tasks, and for all age groups, ". . .cooperation is superior to interpersonal competition and individualistic efforts in promoting achievement and productivity" (Johnson et al., 1981, p. 56). Given the growth of high-involvement, cooperative work settings, the heavy reliance of much of education on interpersonal competition and individualistic work, and our current dissatisfaction with school achievement, we need to seriously consider increasing the use of cooperative learning procedures to promote relevance and higher student achievement.

Group activities are especially important because they *require* development and application of such skills as planning, group problem solving, decision making, and interpersonal skills. To be most effective, group activities should first be designed explicitly to improve development of these skills, as well as technical jobs skills. Second, this objective should be communicated to students.

Cooperative approaches and group learning techniques can be used also to supplement individualized instructor assistance. They can provide timely help to students to overcome barriers or impediments to learning which, if ignored and allowed to accumulate, could lead to frustration, boredom, and ventually to failure and dropping out.

Integration.

Ultimately, and ideally, the sociotechnical perspective presented here would seem to require an *integrative, multi-discplinary* curriculum and a holistic approach to the delivery of instruction. Such an approach that pulls together various subjects, disciplines, and perspectives does not now exist in the schools.

The sociotechnical perspective provides a broad unifying theme and compels teachers and learners in different disciplines to collaboratively search for and focus on the knowledge, issues, and understandings their disciplines all share in common, rather than to emphasize only the differences and uniqueness of their separate subject areas. It seems especially important that we begin to identify *connections* among science, social studies (especially economics and civics), and vocational and practical arts subjects because so little currently exists in these areas. Also, it seems important to identify the relationships of the knowledge and skills developed in these several disciplinary areas to the engineering, human resource development, and business management functions of the workplace. Team teaching and an applied, hands-on instructional approach would seem to be helpful to further facilitate achievement of the desired connections and integration of extant subject matters. Moreover, traditional, compartmentalized vocational service areas (i.e. trade and industry, agriculture, home economics, business and office, and marketing programs) each focused on specialized job skill development, do not appear to be well-suited to the development of higher-order, sociotechnical skills. A comprehensive, integrated core program of vocational education would seem to be needed to focus on development of basic skills and the sophisticated skills, judgments, and initiatives noted earlier as required by more competitive, highly technical and flexible workplaces.

The sociotechnical perspective, along with research conducted by Campbell, et al (1982) showing that most students pursue vocational programs for a variety of legitimate reasons and only a small number seek preparation for a specific job, suggest the need for a branching vocational program sequence. Such a branching program would have multiple program goals and options following from a core program of sociotechnical studies. Program opinions--branches, lattices, alternatives--might include an entrepreneurship option or sequence, a spectific job preparation option, and a career exploration or avocational option. All, except for the job specific preparation option, represent broad-based, integrative vocational programs rather than single-track, occupational service area programs.

Higher-order skills such as problem solving, critical thinking, and decision making do not appear to be simply extensions of a list of basic skills. Rather, higher-order skills seem themselves to be different integrations and combinations of more abstract basic skills into larger, meaningful (purposeful) behaviors and applications.

Basic Skills	**Higher-order Skills**
• *Dis*-integrated	• Integrated
• Abstract	• Applied
• Purposeless	• Purposeful

Thus, by focusing on the development of higher-order skills through the purposeful integration, application and use of those skills, vocational education might, at the same time, meet its expectations to enhance and reinforce basic skills. It would not merely repeat learning that should be taking place in the academic program, but could provide a realistic alternative approach to learning.

Summary

In contrast to the more popular notion of technological literacy, sociotechnical literacy seeks a balanced treatment of the human social and demographic aspects of work, as well as the economic and technological aspects, and focuses on a better understanding of their interactions. It emphasizes development of a broad perspective and understanding of the nature of technology and work in a democratic, technologically advanced society. It also emphasizes development of broadly applicable, highly transferable skills and knowledge--such as group problem solving skills, business economics and operations, and an understanding of the participative management perspective--needed to function effectively in such a society and workplace.

Sociotechnical studies respond to social, demographic and economic trends and to what Reich, Trist and others have noted as a transformation of our traditional technocratic bureaucracies. Such bureaucracies, with their mechanistic authoritarian control structures and the tendency to debase human resources, are being changed into new participative organizational structure better suited to life in a competitive global economy. Such participative organizations depend for their competitiveness not on physical hardware which can be duplicated anywhere, but on human software which can retain a technological edge.

Finally, we speculated on a number of approaches for implementing sociotechnical studies within schools. *Infusion* of sociotechnical skills into existing and ongoing classroom and laboratory experiences was discussed as an immediate and practical way to begin developing such skills. The *application* and use of skills and knowledge under as wide a variety of conditions and circumstances as possible was discussed as leading to mastery and to the transfer of skills to various and novel situations. Vocational and practical arts programs have a special responsibility here because they unparalleled opportunities among school subjects for hands-on approaches and for extensive practical applications and practice. We tried to emphasize the need to greatly increase the use of *cooperative learning procedures* to promote relevance and higher student achievement. And we concluded with a brief discussion of the potential value of an *integrative, multi-disciplinary* approach to curriculums; one which attempts to focus on the connections and shared content among school subjects rather than their differences and uniquenesses.

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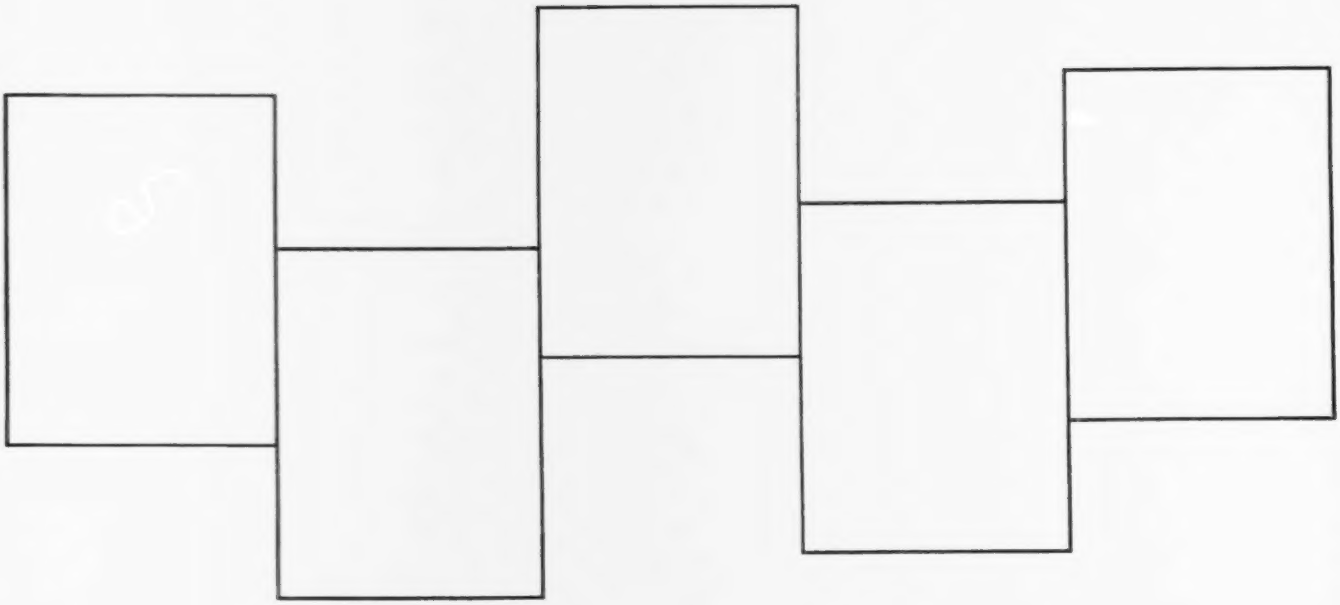
Identifying and Organizing the Content of Technology



A Global Model Of Technological Literacy

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Models are frequently used to express relationships of various factors that supposedly play integrated role to perform some function. They provide great help particularly in complex situations where human perception fails to see interrelatedness of several elements apparently percieved as separate entities.

Technological literacy tends to be a complex concept especially when hundreds of definitions have been offered leading to a great amount of confusion and distortion. Technological literacy consists of two words; technology and literacy, each of them has specific meaning in the contemporary literature. Particularly, the term literacy has classical meanings of having ability to read and write. But for our purposes, the concept needs to be broadened to incorporate the ability of demonstrating specific attitudes and skills other than merely reading and writing.

For our purpose the technological literacy is defined as "The knowledge of the current technical means being used in human adaptive systems; skills to use and create such means; and the ability to comprehend the potential systematized effects of these means and to find the ways of controlling their adverse impacts on civilization." Two key words used in the definition need to be explained. Technical means include any tool, machine, technique, and resource that can be used to solve a problem. The human adaptive system is a man-made ensemble of technical means arranged on set rules to perform a pre-defined function.

Another major problem is encountered due to the fact that technological literacy is heavily context-bound and its meanings vary from one situation to an other. Technology is a social reality grounded in local socio-economic conditions and hard to translate without understanding the context. Gomory (1983) makes this point very clear:

> In dealing with technology, things are sufficiently complex that is done by rule of thumb and not by precise knowledge. . . . technology is cultural-dependent in other ways. Cultural factors such as attitudes towards financing (long term versus short term goals), Attitudes toward carelessness and small mistakes (quality), and the presence or absence of the NIH (not invested here) syndrome (It is hard to get someone else's idea into your laboratory) have a tremendous influence on technological progress. (p. 579)

With the change of context the function of technological literacy also changes due to the different nature of technological progress. The nature of technological progress, socio-economic context, and the function of technological literacy are, therefore, interrelated. Their relationship might be easy to understand with the help of a global model of technological literacy.

A three dimensional matrix represents three unique elements of technological literacy. On one dimension, technological systems can have any set of human adaptive systems are sub-systems such as manufacturing, construction, transportation, and communication, etc. Under no circumstances should this list be considered as an exhaustive of technological systems. It is left rather open and flexible in order to take any set of prevailing systems that happen to be important in local context.

Yoho (1967) defines system as "The total combination of element necessary to perform an operational function or as a total 'set' of interacting elements". The use of system approach to represent technology is not a novel idea. Ellul (1980) gives the logic of using the term "system" to describe technology:

> I chose the term 'system' to describe technology in present day society, it is certainly not because the word is fashionable now, but because I feel that it fits technology. It is

> an indispensable tool for understanding what is meant by 'technology', while disregarding the spectacular, the curious, the epiphenomena that make observation impossible. . . . The system thus involves a choice of symptoms, factors, and an analysis of their relationships. But it is not a mere intellectual construction. There is a quite definitely such a thing as a system. . . (p. 78)

Ellul's definition of system extends beyond what a common person can observe or at least feel. His system is inclusive of every thing in the environment. It is open and non-repetitive. It modifies the other elements by being constantly innovative. Technological system, he believes, is "just as there was a disease expressed in a correlation between the systems that could be grouped and labled" (p. 78).

DeVore (1983) has more practical view than Ellul and explains systems as "composed of elements that are related and which interact in some way. . . . This means that there is some context within which an element, particle, person, tool, event, action, or some other part of a system, acts, and is acted upon. Percieving the dynamics of a system requires the identification of some central theme, function, or benavior" (p.176).

There is a tendency to see the present technological systems as a mere extension of old mechanization. This misconception leads to a narrow understanding which fails to realize the far-reaching effects of technology. Ellul (1980) in an effort to eliminate all these misconceptions, "Technology conceived of its automation, its chemical transformation of the world, its economy of the energy, its cybernation, its data processing, its biological intervention, and its indefinite output of nuclear energy has little to do with the old industrial mechanization" (p. 4).

New Encyclopedia Britannica has developed a standard method for surveying the technological experience and innovations as it is depicted in the history of mankind. The method begins with a summary of the general social conditions of the period, and then goes on to discuss the dominant materials and sources of power of that period. It particularly mentions the application of dominant materials and sources of power to "food production, manufacturing industry, building construction, transportation and communication, military technology, and medical technology" (p. 25). The identification of different human adaptive systems provides a valuable insight for curriculum developers in the field of technology education.

Towers, Lux, and Ray (1966) in the document *A Rationale and Structure for Industrial Arts Subject Matter* present an intensive review of literature which includes discussion on several schemes of classifying the content of technology. They, by using a three-point criteria (all inclusive, mutually exclusive, and operationally adequate), come up with two broad systems, i. e. manufacturing and construction. They concluded that all other systems in the realm of industrial productive processes are the subsystems of the two major systems. Their intent to be highly logical and precise pushed them to define technology in a narrow and restricted sense. However, the impact of their thought on curriculum development is far reaching.

The Jackson's Mill Industrial Arts Curriculum Theory is based on four technological systems, i. e. manufacturing, construction, communication, and transportation. These systems constitute the content of several present industrial arts/ technology education programs and suffice to define our content.

The second dimension of the matrix stands for functional aspect of technological literacy titled as "knowledge function". It answers the questions such as: What are the objectives of technological literacy?, What factors attribute to prepare a technologically literate person?. Several attempts have been made to come up with a comprehensive list of such attributes. A serious and perhaps the first effort was made by Halfin (1973) in order to identify and then operationally define the the processes of technologist assuming that the knowledge of such processes will help students learn about the technological society. After in depth review of the writings of top ten technologists Halfin prepared the list of seventeen processes: (1) defining the problem or opportunity operationally , (2) observing, (3) analyzing, (4) visualizing, (5) computing, (6) communicating, (7) measuring, (8) predicting (9) questioning and hypothesizing, (10) interpreting data, (11) constructing models and prototypes, (12) experimenting, (13) testing, (14) designing, (15) modeling, (16) creating, and (17) managing. Halfin's findings laid the foundations for subsequent curricula. However, many of the processes such as observing, analyzing, visuaizing, computing, etc., have no specific meanings to represent technological actions. Instead they are frequently used in science and mathematics and tend to mean different concepts.

Maley (1983) identifies four significant roles a technologically literate person should play:

1. *The user role*: involving the safe and effective use of materials, tools, machines, households items, and the means of recreation.

2. *The consumer role*: as related to the purchasing and decision making related to homes, appliances, cars, entertainment media, furniture, tools, clothing, and food.

3. *The producer role*: involving the tools, materials, and machinery of agriculture, manufacture, commerce, and service.

4. *The voter or decision-maker role*: involving how to choose between alternatives in community development, energy forms, transportation modes, trash and waste disposal, housing, communication systems, resource development, production processes, and so on. (p. 4)

Northwest Regional Educational Laboratory (1984) published the list of technological literacy skills that everyone should learn. It includes three major categories of such skills:

1. *Attitudes or generic skills that can be taught in any class:* accuracy and precision, anticipating needs, creativity and imagination, critical thinking/problem-solving, ethical standards/confidentiality, life-long learning/retraining, synthesis of information systems, thinking, and troubleshooting.

2. *Applied skills required direct instructions as well as practice under various conditions:* computation and calibration, layout/design, listening, measurement, speaking, and writing.

3. *Specialized skills that may require the expertise of someone who knows what to do and how to teach it:* evaluation and software, file maintenance, keyboarding, networking, search and retrieval. The ideas may better be expressed by using the term computer literacy which is just a part of technological literacy.

Smalley (1986) perhaps was the first person who really prepared a test of technological literacy. By using Delphi method, Smalley reports nine criteria for technological literacy test:

1. connect past technological events to the present and be able to project alternative future;
2. be able to solve technological problems;
3. be a wise consumer/decision maker concerning technological products/services;
4. understand the implications of career choices in the field of technology;
5. understand reading materials in technological areas written on the 10th grade level;
6. apply technological knowledge to a variety of human concerns and situations;
7. knowledge of existing and emerging technologies;
8. able to evaluate technologies as to their appropriateness in our world; and
9. able to understand and adapt to change brought about by technology. (p. 53)

An careful review of literature on the purpose of technological literacy indicates that the ideas presented in these discussions can be grouped under four general functions of technological literacy. These functions, i.e. interfacing technology, using technology, making technology, and controlling technology can be called "knowledge function" as the basis of their performance is knowledge gained through formal and/or informal education.

Contrary to the standard meanings, the connotations used to express these functions bare special meanings and an explanation of such meanings is in order. It should, however, be remembered that the model, by its nature, is a simplified version of the reality. Specific meanings have to be attached by explaining the model so that the model can remain simple and easy to understand while rich conceptual formation. In the following paragraphs the four functions are explained as follow:

1. *Interfacing technology* includes a readiness to interface new technological objects and subsequent change in the individual attitude to cope with them. It also requires updating the knowledge about technological world through observation, experience, and reading appropriate material.

2. *Using technology* necessitates the wise selection of technological objects and their proper and efficient use. It also includes using technology in a problem-solving situation especially in unpredictable circumstances. Using technology encompasses individual, local, national, and global level depending upon the social responsibility of an individual.

3. *Making technology* stands for not only making and inventing appropriate objects, tools, and systems but also means innovating/discovering new technologies to solve practical problems at different levels.

4. *Controlling technology* is controlling of all undesirables internal and external interventions in the social order created through technology. It also emphasizes the ability to look inside to discover hidden and delayed side effects of larger systems. The individual should also be able to develop means to effectively control negative effects of technology.

The third dimension of the global model of technological literacy signifies the importance of socio-economic conditions of a particular geographical area in which technological literacy is being pursued. The vital role that a social structure plays in the technological development has frequently been discussed by numerous writers. *Encyclopedia Britannica* describes the social involvement in technological advances under separate subheading and notes, "To simplify the relationship as much as possible, there are three points at which there must be some social involvement in technological innovation: social need, social resources, and a sympathetic social ethos. In default of any of these factors it is unlikely that a technological innovation will be widely adopted or be successful" (p. 24). Since the technological literacy takes its meanings from the technological development, the socio-economic conditions constitute an inevitable ingredient.

The significance of socio-economic context is also very evident from the writings of other eminent scholars. Gilberty (1986) believes, "How technology is applied depends on what society thinks it is, what its limitations are perceived to be, what is its role in society, and how that role is assessed" (p. 22). Schooling can play an indispensable role in spreading technological literacy. But Pogrow (1982) is skeptical about this, "History suggests that a technology will play a central role in the public schools if--and when--it first gains cultural acceptance, i. e. admittance to a large number of homes and becomes a primary work tool" (p. 610).

The classification of underdeveloped, developing, and developed socio-economic context is merely tentative and can be replaced by better descriptors. However, if a decision is made to use the proposed classification, the above referred criteria (social need, social resources, and a sympathetic social ethos) may be used to distinguish one class from the other in terms of the level at which they meet the criteria.

The decision of labeling a country or a particular geographical location with such descriptors as developed or underdeveloped possess several questions about the validity of such demarcations. It is beyond the scope of this study to devise a valid or empirical method for doing such activity. However, sociology or economics may have some better ways to do this.

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Defining, Determining, and Contributing toTechnological Literacy: Getting There From Here Using theTechnology of a Research Paradigm

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Technological literacy. It has a nice ring to it. Like motherhood, the flag, and apple pie, most people would probably say they were for it. When pressed to define it, the man or woman on the street or the scholar in the classroom or research laboratory is operating with similar handicaps. The "it" of technology literacy is defined situationally. The man or woman on the street will define it in terms of their needs and perhaps the needs of their children. They may offer that technological literacy is being able to use a computer, drive a car, program a VCR, or know when something should be taken to a professional repair technician. The layperson typically defines technological literacy as being able *to use* equipment and things that individuals will come into contact with during their daily activities and to know how things work and what one needs to do to maintain or obtain control over things or processes.

The scholar, on the other hand, will tend to define technological literacy in terms of his or her discipline. The historian will point to the significant connections between people, ideas, and inventions. The political scientist will note that to be technologically literate involves knowing about such things as the constitution and the individual's rights and responsibilities to influence and even create governments. Scientists in physics, chemistry, biology, astronomy, and any other science-based discipline will point to the need to know the makeup and interaction of our physical world. Mathematicians will point to the basic language of numbers and the need to be equipped to deal with numbers and data relationships in a complex technological world. Industrial arts teachers, vocational and career education teachers, art teachers, music teachers, and other teachers of the non-academic areas will point to the critical contribution that their subject makes to the literacy of the individual and the competencies of the individual to contribute to, and function in, an increasingly complex and technological world.

Defining technological literacy is then an interesting problem. Some would suggest that defining the term is not really possible or necessary and may even limit the political support for technological literacy if it is defined too narrowly (Beaver, 1986). Others go to great lengths to differentiate between scientific and technological literacy (Roy, 1986; Miller, 1986) and others appear to equate (Peterson, 1986) or at least assert the foundational and prerequisite nature of science to technological literacy (Missimer, 1984).

One of the major questions related to the definitional parameters of technological literacy should be "What can we do about reducing this confusion and noise about what technological literacy is?" If we can't define what it is that is needed, then we will have serious problems in directing research, curriculum development, legislative support, or the public's attention to our version of motherhood, the flag, and apple pie.

I am suggesting that the systematic process of research will provide us with the answers to our current dilemma in dealing with the technological literacy patchwork of concepts, goals, criticisms, and curricula approaches. In my management consulting practice where I work with managers and employees to identify strategies to improve productivity, the problem of what it is that an organization wants is much more crucial than what it does. This directional imperative has come to be called the mission of the organization. Without a clear definition of this mission and purpose, most organizations, and the leadership of those organizations, are no better than Alice in Wonderland in her pursuit of the White Rabbit.

As you may recall, Alice was constantly losing sight of the elusive White Rabbit and at one point is faced with the decision to take one of two roads. The Cheshire Cat, most likely Wonderland's version of an organizational consultant, is perched in a tree when Alice asks,

> ". . .would you tell me, please, which way I ought to go from here?"

> "That depends a good deal on where you want to get to," said the Cat.
>
> "I don't much care where -----" said Alice. (Carrol, 1955, p. 29)

The sage in the tree concludes then, that it matters not which road she takes because either will take her where she does not know she is going.

In the public schools and the universities, we often pursue different roads with as little forethought as Alice in Wonderland. However, during these times of scarce resources and the need for dramatic improvement in a variety of educational areas, this lack of direction is a luxury that we and our students can ill afford. An educational program needs to be designed for *all students*, especially the majority who will not be well served by more of the same "stuff" with which they have not been successful (Albrecht, 1984). All students, not just the advanced technician or the scientist, will live and attempt to function in a *variety* of life roles in an increasingly complex and often hidden technological world (Lux, 1977). Vocational education, industrial arts, and the whole purpose of the school must again be focused on the students and their needs for *all* of their life roles (White, 1978).

Educators, researchers, curriculum developers, and teacher educators must be able to define the goals and develop approaches that will enable students to systemtically pursue them (White, 1979). I am suggesting that one way to figure out which road to take would be to design a research model that would help us to uncover the variables associated with technological literacy and then to systematically construct research studies that would identify, codify, and enable tht reality of technological literacy so this all important objective can effectively be addressed by educational programs.

Since a model must serve as an approximation of reality, any model will have its weak and strong points. However, it should be able to explain reality better than we can in the absence of the model (Lippitt, 1973). Ideally, models should enable us to learn more about the focus of the model than we can without the model. It should also enable us to communicate the major components of the idea to others, who may not have the same focus we do. This is especially true when one requires public support and understanding of the model to obtain the resources necessary to implement solutions identified by the model. McGrath (1972) gives eight criteria for a model.

> 1. A model is a replica of some sort.
> 2. A model is an agreed-upon symbol of some sort.
> 3. A model provides an habitual form for thinking or for conceptualizing about something.
> 4. A model is a shortcut or an economy in thinking or for conceptualizing about something.
> 5. A model may be either complete or incomplete.
> 6. A model may be either simple or complex--or somewhere between, depending in a large measure upon the user and his need.
> 7. A model provides for standardization and control of conceptualizations, processes and definitions; it is a nomothetic structure or system.
> 8. A model is a means; not an end. (p. 16)

The model to define, determine, and contribute to technological literacy is a road map designed to meet all of McGrath's characteristics. It is to represent the reality of the environment of the technologically literate individual; it is a symbol of reality upon which we can perhaps agree; it will offer us a way of thinking about technological literacy; it will be complete (yet adaptable and amendable as technology itself is); it will be a relatively simple model in context while a little more complex in contentual relationships; it will provide for standardization of the factors and variables associated with technological literacy; and finally, the model will be a means to an end. It will be a tool to help researchers know more about the variables associated with technological literacy and to then be able to know which variables need to be studied and later manipulated to bring about technological literacy and ultimately individuals who are more in control of their own lives and the technology that enables and impacts on those lives.

Since technology is "the means by which humans utilize natural and human resources to attain a goal" (Roy, 1986, p. 133) and literacy is the understanding and ability to use the code of communication that is standard in the culture (Haberer, 1986), technological literacy must be the ability to *understand* and *use* the code of those means by which humans utilize natural and manmade resources to attain a goal. The debate generally comes from *what* should be understood and *how* technology should be used.

Technology is a very broad term. So is literacy. Both terms are very situational. The technology of char fishing employed by the Inuit people in Cambridge Bay in the Northwest Territories (NWT) is quite different, and probably culturally and technically content specific to that culture by the people who have learned what works and under what conditions it works. The trout angler in the hills of Pennsylvania needs to be literate in a culturally different type and purpose of fishing if she expects to be effective and efficient (what we have come to identify as the two components of productivity). Catfish farming, using high tech fisheries technology systemizes, routinizes, and perfects the technology of fish-for-food much beyond the literacy stage to the technician, technologist, and applied science level of performance. Technological literacy would be defined quite differently for the Inuit fisherman, the Pennsylvania angler, and the technician feeding 500,000 week old catfish in Georgia.

The major problem of the educational system that is producing tomorrow's leaders, as well as tomorrow's citizens, is to figure out what people need to be able to know and do to be productive in their *various* life roles and how the school can best provide the experiences to enable that individual to be productive. Literacy is the foundation of that productivity. Math and science are often suggested as the foundation of literacy attainment (Missimer, 1984; Peterson, 1986). Language of and about technology combined with the skills associated with the use of language--the vocabulary, the forms and patterns, and the information storage, retrieval, and exchange--are also cited as prerequisites to technological literacy (Smith, 1986). Knowledge about politics and the operation of governments is defined as a necessary literacy to be a functioning citizen of a technological society (Nelson, 1987). Competencies in ethical decision making and values (Adams & Baker, 1986) and in vocational and the industrial arts (Dyrenfurth, 1983) are also cited as crucial to fully functional and literate individuals in a technological society. Some would suggest (Gies, 1982; Lewis, 1983; Miles, 1984) that technological literacy is the true liberal arts for the 21st century.

Since the beginning of recorded history, there have been differences in the capabilities and, subsequently, the interests of peoples and cultures. The Greeks even defined city states for these different strengths--those who did were Spartans and those who thought were Athenians. While this analogy was and is unfair to both, the differentiation has continued and been formalized through the development of educational systems in Europe and eventually in the United States.

Even in this century, all attempts to legitimize and attract *all* students to the "doing" components of education have been segmented at best and, during the current Washington administration, even a net loss and mean spirited at worst (Swanson, 1987). Even massive federal funding of vocational education and career education has not democratized the doing component of education. Vocational education, industrial arts, and home economics are seen as "OK for someone else's child, but not mine." In response, these curricula areas have tried to "get back to the basics" or become more like their Athenian counterparts by worshipping at the altar of science and math and declaring that technological literacy is one of the "real" purposes of their efforts.

Like many educational trends, however, we may be throwing out the baby with the bathwater as we push our programs into and beyond technological literacy. This is especially hazardous if we don't know what technological literacy is and we are willing to accept someone's "test" (Gies, 1982) of knowing facts as the measure of technological literacy. We must remember that "in its broadest sense, technology can be defined as the practical arts and skills of human society" (Slaght, 1987, p. 38).

Technology is not just lasers, robots, and semiconductors. It is also housepainting, cooking, tool usage, and safety. In the debate about and for technological literacy courses, "let us not confuse courses *in* technology, where a technology itself is taught and mastered, with courses *about* technology, where a technology is examined and evaluated, but seldom learned" (Slaght, 1987, p. 38). *Both* are required for a truly liberal education. It is education that frees people from the lack of control over their environment and contributes to meaningful understanding that comes from being able to do (Lux, 1981; White, 1984).

There is still the elitism of the "liberal arts." Industrialized societies are now paying the price for this elitism in that we have leaders and decision makers in all organizations who have little or no experience in the business of the organization. This is especially damaging in the manufacturing component of industries. The lack of "shop floor" reality experience has been cited by numerous sources

(Schonberger, 1986; Drucker, 1986) as one of the major reasons that the United States has fallen behind the Japanese and the Germans. If any of these problems are going to be "solved" by "technological literacy" educational programs, then it is imperative that we go about designing, implementing, and evaluating these efforts in a systematic way. The research model presented here will enable that process to begin.

A Model for Researching Technological Literacy (MRTL)

We technologists are practical people. Most of us selected life roles (careers, leisure, or otherwise) that enable us to engage the practical on a regular basis. Models, model building, and the use of models is not new to most of us. We have used plan sheets, blueprints, scale models, systems models, PERT, CPM, and a variety of other models to enable us to visualize, manipulate, and control our technological world. This Model for Researching Technological Literacy (MRTL) is like these other tools that we have used to enhance our capability. MRTL will enable us to enhance our knowledge about and our experiences with technological literacy. It will be a valuable tool to enable us to think systematically through the complex maze of technology so we may better know the focus of our efforts and be able to measure those efforts and their results. It also can and should be, like all tools, continually refined and reapplied. The purpose in presenting MRTL is to enable people to DO. . .to do research in the area of technological literacy.

Since Technological Literacy (TL) is very complex, a model is an ideal way to help us understand and contribute to TL.

> Basically, a model is a symbolic representation of the various aspects of a complex event or situation, and their interrelationships. A model is by nature a simplification and thus may or may not include all the variables. It should include, however, all of those variables which the model builder considers important and, in this sense, models serve as an aid to understanding the event or situation being studied. The true value of a model lies in the fact that it is an abstraction of reality that can be useful for analytical purposes. (Lippitt, 1973, p. 2)

Since all models use symbols, the symbols and the relationship of the symbols to each other are important. With MRTL you will see a process flow from the beginning to the end. At each stage of the model, decisions are made that impact on the next stage and are predicated on the decisions that have been made in the previous stage. In a sense, these stages of MRTL are like different sized foundry riddles permitting increasingly finer focus as we progress through the various screen sizes. (See Figure 1)

Recognizing the foundational aspect of cognitive competence and the situational nature of this in the process of technological literacy (Ray, 1986), the first stage of MRTL is the *Cognitive Competency Level* (CCL). This stage of the model requires the model user to identify the *level* and *area* of competency that is of interest. Since these are on a continuum, it is possible for the model user to be interested in a given *range* of cognitive competency and ability within specific subject matter areas. This CCL stage of the model recognizes that all people are different and that in different situations some who are "smart" are "dumb" and some who are "dumb" are "smart." This mirrors the reality that we have all experienced in ourselves and in our students.

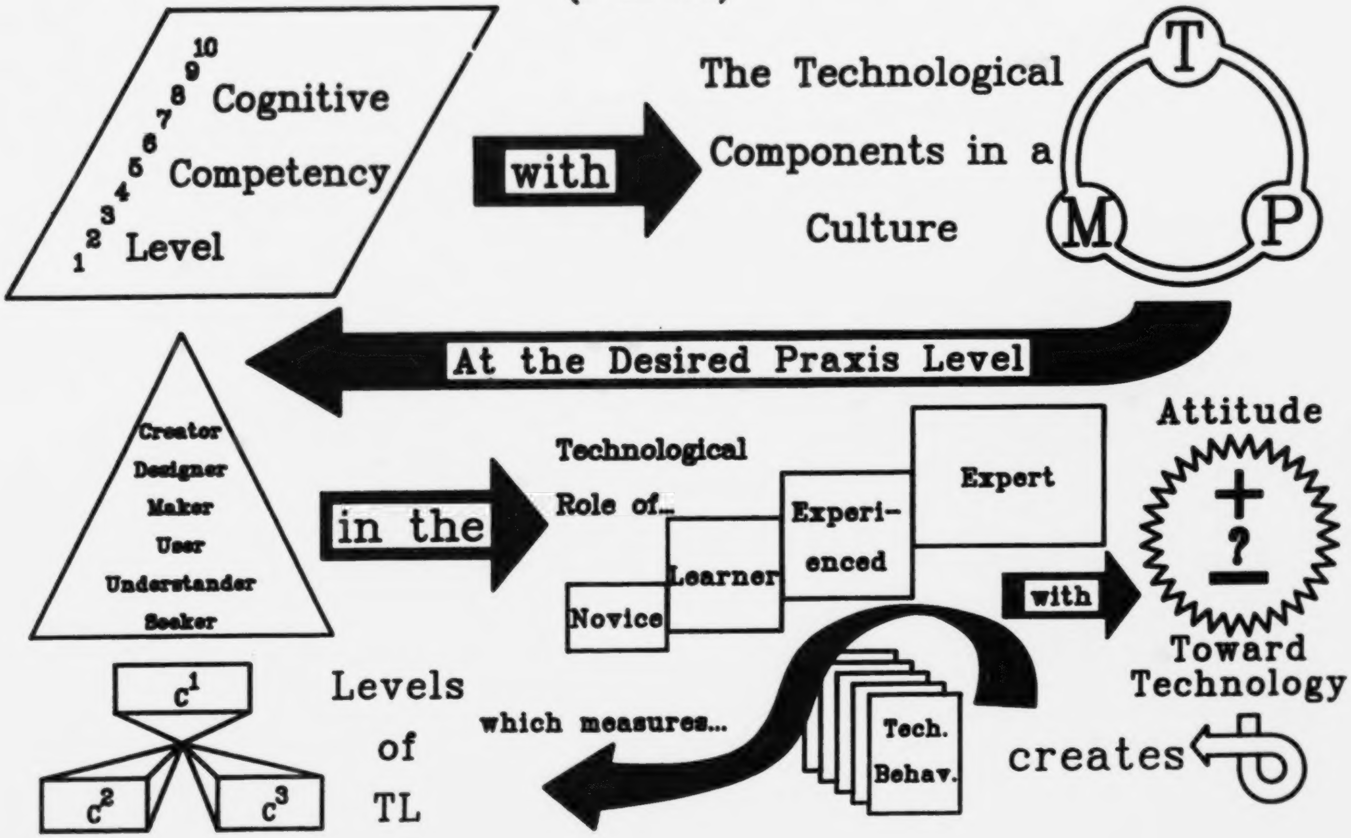
In this first stage, there are 10 levels of competency from which the researcher selects, or systemtically groups, to determine at what cognitive competency level the research is going to be conducted. These levels are:

1. Is ignorant
2. Is aware
3. Knows facts
4. Knows relationships within and between facts
5. Knows universals and abstractions
6. Manipulates knowledge
7. Applies knowledge
8. Analyzes knowledge
9. Synthesizes knowledge
10. Evaluates knowledge

For example, if the researcher was interested in determining who in a population had the *Cognitive Competency Level* (CCL) of "Knows facts" about the technology of nuclear power generation, then questions about those important facts would be constructed at this stage of the model. Most so called "technological literacy" or "scientific literacy" tests deal *only* with the content and the competency at this level and this level only (Gies, 1982; Peterson, 1986).

When the levels of cognitive competency are determined and perhaps categorized into types of

A Model for Researching Technological Literacy (MRTL)



1 2 3 4 5 6 7 8 9 10 Cognitive Competency Level

with

The Technological Components in a Culture

T M P

At the Desired Praxis Level

Creator
Designer
Maker
User
Understander
Seeker

in the

Technological Role of...

Novice

Learner

Experienced

Expert

with

Attitude + ? − Toward Technology

creates

Tech. Behav.

which measures...

Levels of TL

c^1 c^2 c^3

knowledges required (language, mathematics, physics, chemistry, etc.), one then goes to the next stage in the model of selecting the *Technological Component in a Culture* (TCC). These depend greatly on the situation upon which one wants to do research. Given the above nuclear power generation example, we could focus our research at this stage on the *Tools* (devices), the *Processes* (mining, refining, shipping, using, generating, cooling, waste managing, material handling, etc.), or the *Materials* (fuel rods, containment buildings, distribution networks, etc.) of the technology of nuclear electrical generation. Since our example CCL is "knows facts," a logical TCC could be "about the process of nuclear power generation from mining to distribution and waste handling."

Given the TCC and CCL results, we are now ready to consider the third stage of MRTL: the *Desired Praxis Level* (DPL). This stage of the model enables us to go beyond what most research in TL is capable in that we have a way to determine what proficiency level we want to test, measure, or set for our research efforts. The levels of DPL are:

1. Seeker
2. Understander
3. User
4. Maker
5. Designer
6. Creator

In our nuclear power generation example, *given the decisions at the previous two stages,* we are likely to be considering the lower level DPLs of Seeker, Understander, or User. The research would then be further focused by the DPL to "uses resources to gather information (technical, financial, environmental, etc.) about nuclear power generation."

Since, in a technological society, we all function at various levels of technological literacy in our multiple roles, the role must be considered when doing research about TL. This stage of MRTL is called the *Technological Role* (TR). The four levels of TR are:

1. Novice
2. Learner
3. Experienced
4. Expert

While the upper two levels might be classified as "occupational" roles and the lower two as "citizen roles," this would *not* be correct to all situations. One is frequently faced with an individual who occupationally does not use the "expert" role that he or she has attained, at the maker or designer praxis level, with tools and processes, using analysis and synthesis cognitive competence. Nonetheless they have attained the expert role in that technology. In our continuing example of nuclear power generation, again *given our previous choices,* we are probably interested in the novice or learner level and our interest may be addressed as: "Aware of the processes involved in nuclear power generation and attends public hearings and forums on plant initiations."

The fifth level of MRTL is the *Attitude Toward Technology* (ATT). Together with the selected *Cognitive Competency Level* (CCL), with the *Technological Components in a Culture* (TCC), at the *Desired Praxis Level* (DPL), in the specified *Technological Role* (TR), it asks the question: "What attitude toward technology is predicted, desired, optimal, etc.?" (This decision is dependent on the researcher's purpose for using MRTL.) If, in our example, we want to be able to create a curriculum that would provide a positive attitude about nuclear power generation, then we might derive the following from this ATT stage: "Expresses optimistic views about nuclear power generation."

Other decisions at this stage might be research decisions to find populations with a specific positive, negative, or neutral attitude toward a particular technology and then trace back through the model for correlations and antecedent variables that might be useful in predicting the specific attitude formation under study. It should be noted that although the model displays only three majors *directions* of attitude (positive, negative, or neutral) there are multiple and perhaps infinite *strengths* of each of these directions that the researcher needs to consider in using the ATT level of MRTL.

MRTL has now brought the researcher to the stage where the research problem, hypotheses or research questions, the variables of the study, and the population of the study can be identified and systematic research procedures can be created to *measure* technological literacy at one of three levels (Roy, 1986).

C^1 Comfortable *with* technology,

C^2 Competent *in* technology, or

C^3 Control *of* technology.

Roy (1986) discusses these three levels or states of technological literacy as unique to each other and yet related to each other. *Comfortable with technology* is that ". . .state in which a human being is at home with, the technological means that she or he uses, but unable to assess their impact on persons or society" (p. 133). The other end of this "comfortable" continuum is "uncomfortable with technology" which is defined by Roy (1986) as a ". . .state where due to ignorance, one is both wary and afraid of even the means one must use on a daily basis to attain one's goals" (p. 133).

The second level of *competent in technology* denotes the acquisition of the necessary cognitive, attitudinal, and psychomotor skills to function and operate effectively with the technology to attain one's goals. The third level of *control of technology* builds on the competency attained in level two and enables the individual or group to display behaviors that demonstrate to the researcher that the subject(s) can achieve a high level of cognitive understanding of the technology and can ". . .shape or adapt it as necessary to achieve even new goals based on an assessment of its potential for good and ill" (Roy, 1986, p. 133).

With these three levels as behavior indicators, the researcher has a construct to create or discover measures of technological literacy *in conjunction with* the other decision points in MRTL. Independent and dependent TL variables are more easily identified using the MRTL than without the model. The MRTL permits some standardization and control of the conceptualization process and helps the researcher to define terms, processes, and systems within the TL area of study. The MRTL, while a simple model to use, still addresses the complexities of TL and enables the researcher to adapt to the technology under study, the diversities of the population, the multivariate nature of TL, and the different ways to measure TL. To a great extent the *Model for Researching Technological Literacy* may serve as a useful tool in conceptualizing and creating systematic research to answer the questions of "What is technological literacy?" and "How do we teach it?"

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What Price Progress?: The Social Impact of Technology on Society

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Industrial Arts Education had a mandate to interpret industry. Technology Education, as successor to Industrial Arts, inherits that still valid mandate.

Changes in technology produce changes in industry. Some of these effects are social, and the social impact on society of the changes brought about by technology is becoming as significant a factor in understanding industry as the economic impact traditionally studied.

Man and Technology: A Suggsted Course

In order to facilitate the understanding of industry it is suggested that a course be introduced entitled *Man and Technology*. The course would consider the implications of specific technologies in industry for the improvement of our standard of living (the "SO WHAT" content). The course, part of a suggested curriculum in general education called PRODUCTION SCIENCE, was described, broadly, in an article by this author in the February, 1985 issue of *The Technology Teacher*. A justification for including this curriculum as part of a person's general education is offered in DeVore's (1983) statement on the power of technical knowledge.

> If we are to remain as free citizens in a democratic society and control our own destiny, then it is important that we control our technical means and direct and use them to attain agreed upon social purposes. To do otherwise will bring about a society controlled by an elite group who are knowledgeable in creating and controlling technical means for their purposes. (p. 11)

Also described was the remainder of the curriculum, the study of production techniques, using laboratory courses to demonstrate the use by industry of materials, tools, and processes to improve products and productivity (the "HOW" content). As this paper is limited to describing the implications portion of the curriculum, production techniques will not be discussed further.

Course Criterion

One way for a course on Man and Technology to carry out the Technology Education mandate to interpret industry is to select an industry (e.g. communications), and then determine the effects on the industry of a new technology (e.g. fibre-optics), and the social effects of both on the society (e.g. creation of jobs in fiber-optics, potential invasion of privacy).

However, so vast is the number of technologies, industries, and social changes (including, as Maley suggests, the past, present, and future heritage), that some criterion must be established for selecting which technology, which industry, and which social change (including whether its coming, going, or gone) should be studied.

The criterion used in selecting a technology or industry for study is its implication for society (the "SO WHAT" content), where that implication appears to be profound.

One example of such implication is the fact that technology has expanded the productive capability of industry. Product development derives, in part, from the capability of the equipment, but equipment is expensive. Therefore, decisions on the introduction of new products are increasingly being made on the basis of what the equipment can produce rather than what products are in demand. Machine capability, not the marketplace, is determining the products to be produced. Demand, itself, is becoming a product, and, like any other other product, it can be manufactured. Markets, therefore, no longer have to be found, they can be created.

Another example of an implication is that industry, for years unmindful of the waste it has created, is increasingly being held accountable for the damage to the environment caused by the toxic wastes it pours into the air and water. This is a reaction, at last, to such dream-shattering realities as that experienced when, finally having the time and money, you take that long awaited trip down the Rhine River to find yourself traveling on what has been called the filthiest waterway in Europe. Much the same is being said of the scenery in the United States and Canada, with action still at the talking stage in eliminating acid rain from the once beautiful streams, rivers, and mountains.

Further implications of technology derive from viewing technology as a benefit, a curse, or a mixed blessing.

The Benefits of Technology

The benefits of technology, briefly, are two:

1. Extension of human physical and intellectual capabilities
2. Decrease in some forms of human physical and intellectual labor

As a result of these two benefits North America has one of the highest material standards of living in the world. We enjoy an increase in the number, quality, and variety of material products, an increase in the value of products, per dollar, and an increase in the opportunity for leisure time in which to enjoy these products. The enormity of these accomplishments can more readily be appreciated when one views the standard of living in other nations.

The Curses of Technology

Society benefits from technology, but it also pays for those benefits. When we consider the problem of acid rain, for example, we consider something tangible. It can be seen and measured and debated and the consequences are obvious. More subtle are those social costs that include the adoption of values that favor industry a lot more than they favor society or that work against being human. One of these misplaced values is the use of the Protestant Ethic by unscruplous employers during the Industrial Revolution, to give a veneer of respectability to what authors like Charles Dickens (*Hard Times*) showed to be the outright exploitation of people, down to the shameful use of seven year old children in the coal mines of Wales.

A particularly dehumanizing behavior in this world of increasing technology is the tendency to imitate industry. One evidence of this may be seen in some people's preference for industrial measures of performance (judgement by checklist) over human measures of performance potential (judgement by faith), in the prediction of future performance. We are forgetting the power of the second chance in turning some "losers" into winners.

Another example of this tendency toward machine worship is offered by Sayre (1984) in his review of the book *Technostress* in which, writing on the attitude of youth toward computers, he noted the author's point that:

> Many of today's youth have chosen the computer as an inspiration role model, rather than a parent or teacher. Children are beginning to accept the computer's speed and efficiency as desirable human traits while completely overlooking the machine's lack of social and creative human characteristics. These children are viewing teachers and parents as being longwinded, boring individuals whose efficiency is very limited. (p. 55)

Another value that is questionable is that developing personal integrity does not seem to be as major a concern of society as developing technical skill. Consequently society is developing skilled mechanics who cheat us.

Another interesting value: people often measure their status by the quantity and quality of their material possessions leading them to be less concerned with purpose or function. As a consequence we see the fascinating phenomenon of people with hearing difficulties owning hi-fi stereos, and people buying products that have the brand names conspicuously displayed.

It looks, too, as though we are becoming servants of our technology. Consider the time spent wondering where you parked the car, how much gas there is in it, what that noise is, where that liquid is leaking from, how competent the mechanic is, how honest the mechanic is, where the money for the repair is coming from, etc.--and that's just the car! How about the house, food, clothing, vacations, gadgets, etc. Finally, there is what may be the supreme insult to the human spirit--people, without fuss, turn over their decision-making responsibilities to inanimate objects. It is perfectly possible to get a ticket for crossing a prairie street at three o'clock in the morning when there is not a car around for miles and it is 30 degrees below zero because you passed a red light. Carried to the extreme, an ominous scenario can be imagined in which the military gives the power to computers to launch nuclear missiles in the event of a hostile military first strike because people cannot be depended upon to have the sangfroid to push the button when the moment comes.

On an entirely different theme, industry is affected by the need for cost reduction and the cost of humans in an enterprise is often expensive. In general, the highest cost in producing a product is the cost of the person producing it. Money is spent not only on wages for productive work, but for wages paid where there is no productive work due to a myriad of human causes including incompetence, immorality, and illness. Examples abound of low productivity due to alcoholism, absenteeism, cheating, stealing, and personality clashes. Wages also vary in accordance with skill and it is a wise worker who makes himself indispensible, and therefore expensive, by increasing the skill requirements of his job. But employers are wise, too, and they are vitally concerned with keeping employee costs down and productivity up.

Concerning skill requirements, "Since the beginning of the Industrial Revolution," Levin (1984, p. 14) noted, "employers have sought ways of reducing the skill requirements associated with work." The work of men like Frederick (Speedy) Taylor and Frank Gilbreth at the turn of the 20th century pioneered the use of time and motion studies to improve productivity, introducing scientific management as a field of study in manufacturing. Industrial engineers often design production lines, not so much for efficiency of production as for simplicity of tasks suited for low skilled labor, for it is more profitable to hire additional low-skilled workers than to produce a product more quickly using highly skilled workers. Low-skilled workers work for less, require less training, and, at the employer's discretion, can easily be replaced.

Concerning worker productivity, it is theoretically possible that if people were replaced in a production line by machines, the profits due to improved productivity would soar to the point where, if those savings, instead of being given as increased dividends to the stockholders were translated into lower selling prices, almost everyone could buy almost anything for almost nothing. In a society in which work is considered a moral good, what will be the effect on people of having work as the privilege of the few rather than the right of all?

As another example of misplaced values, a company's progress often consumes more of an employee's time than his or her children's progress, leading to estranged family life and having children growing up almost without parents.

Excessive concern with a company's progress (e.g. bringing home the company's problems) could contribute problems to one's personal life, increasing, perhaps, the incidence of marriage breakdown, cardiac arrest, or escapist activities (drugs, alcohol, suicide).

Technology as a Mixed Blessing

Finally, technology can be a mixed blessing. Our citizens enjoy an increase in their life span and a reduction in its pain, while at the same time living a life style that, until relatively recently, gave mostly lip service to the idea of fitness and the maintenance of health. People have an increase in leisure time available through a reduced work week, but an increasing number of people spend that leisure time working at a second job.

Implementing the Course

If the proposed course Man and Technology is to be taken by all students then it must be a course acceptable for college admission. Otherwise, no student in the college-bound track will take it. It should therefore probably be offered in the last year of high school.

Discussions designed to understand the implications of technology for improved quality of life may be reinforced by guest lectures of teachers of science, biology, social studies, and economics, and by visits to industrial or government agencies concerned with these problems. Alcorn's (1986) book is an excellent source for ideas on issues for class discussion.

It is emphasized that the class discussions must arise from events occurring during the role-play in company operation. To do otherwise is to risk having the experience degenerate into an exercise in Social Studies taught in a stage setting made up like an industrial factory.

To illustrate how the course has been taught, a course outline is offered in Appendix A. Anyone wishing further information is invited to contact the author.

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APPENDIX A

MAN AND TECHNOLOGY

Course Outline

Instructor: A. Meyers

Required Text: Teich, A. H. (Ed.) (1986). Technology and the future (4th ed.). New York: St. Martin's Press.

Recommended Reading

Brown, J. A. C. (1964). Social psychology of industry. London: Penguin Books.

Packard, V. (1957). The hidden persuaders. New York: David McKay.

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Petit, T. A. (1967). The moral crisis in management. New York: McGraw-Hill.

Pytlik, E. C., Lauda, D. P., & Johnson, D. L. (1978). Technology, change and society.

Worcester, MA: Davis.

General Objectives

Students will develop an understanding of the role of technology in our society.

- Student will be able to describe the factors involved in operating production companies in a technology-based society.
- Student will be able to discuss the impact of technology and society on each other.
- Student will be able to discuss the future of technology.

Specific Objectives

At the end of this course, the student will be able to:

- List and discuss the factors involved in setting up and running a company in a technology-based society.
- Discuss the impact of technology on production methods.
  - organization
  - planning
  - control
- Discuss the implications of technology for future production methods.
- Discuss the changes in values and life styles brought about by technology.
- Discuss the implications of technology for:
  - alternative energy sources
  - environment protection (conservation of natural resources and scenery)
  - pollution control (air, noise)
  - quality of life

General Methodology

The learners will achieve the course objectives by establishing, operating, analyzing, and disbanding a simulated manufacturing company typically found in a technology-based society. Problems arising from the operation of this simulated company will be discussed at a conference session held during the last 1/3 of each daily laboratory period. Learning methods used in this course include: directed discovery, simulation, case-study, role-playing, conference, and discussion. Learning aids include: field trips, guest lecturers, management games, films, library searches, and directed readings.

General Evaluation

At the end of this course, the student will be expected to demonstrate the degree of his awareness of the impact of human beings and technology on each other.

Topical Outline

Unit I: Introduction: Development of a technology-based society

- Elements
- HistoryUnit II: Elements of a company in a technology-based society

Unit III: Organization

Unit IV: Management philosophies

Unit V: Effects of present production system

- Materials supply
- Personal life style
- Environment

Unit VI: Future production system in a technology-based society

- Alternative energy sources
- Change in one's value system
- Change in nature of products

Unit VII: The changing responsibilities of management

Course Evaluation

Presentation *	50%
Participation **	20%
Final Examination	30%
Total	100%

* Presentation

The student will select a topic relevant to the Specific Course Objectives and give a 30 minute presentation to the class. A fifteen minute class question and discussion session will follow the presentation, followed by a fifteen minute follow-up of the discussion, by the instructor.

The student will distribute a one page summary of the presentation to the class at least one week before the presentation, and hand in a typewritten copy of the contents of the presentation on the first school day of the last month of the term.

** Participation

The student has an obligation to share his views and knowledge with the rest of the class. Students are therefore expected to become actively involved in the class discussions and to contribute meaningfully to the class discussion. They will be evaluated by their peers on the quality of their contributions to these discussions.

An International Study of Curricular Organizers for the Study of Technology

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Introduction

> Possible curricular changes emanating from technological changes will require careful study and deliberation over a long period of time. (*Educating Americans for the 21st Century*, 1983, p. 13)

Education in this decade has been dominated by the thrust for excellence in education. Numerous recent reports have called for a complete reform of our total education process. State after state has echoed the report, *A Nation at Risk*, to overhaul their education system. Pervasive throughout these reform movements has been the importance of the study of technology as an essential element for a technologically literate citizenry.

In *Educating Americans for the 21st Century*, the report stressed the importance of technology education directed toward the needs of our future citizens.

> Students must be prepared to understand technological innovation, the productivity of technology, the impact of the products of technology on the quality of life, and the need for critical evaluation of societal matters involving the consequences of technology. (p. 44)

Ernest L. Boyer, in the Carnegie Foundation for the Advancement of Teaching Report titled *High School: A Report on Secondary Education in America* (1983) cited the need for the study of technology that would lead to a more technologically literate citizenry.

> We recommend that all students study technology: the history of man's use of tools, how science and technology have been joined, and the ethical and social issues technology has raised. (p. 110)

Bell (1973) identified that society has transcended from machine technology to an intellectual technology (p. 27). Logically, this affects the way technology curricular organizers should be identified to appropriately represent the study of technology. The present curricula organizers for technology education: construction, manufacturing, communication, and transportation, do not appropriately represent an intellectual technology that is advancing exponentially.

These curricular organizers were derived from an industrial base. Although the industrial implications of industrial arts can be traced back to the Industrial-Social Theory or the Russell-Bonser Plan, Warner's curriculum organization has been the most widely accepted within the industrial arts profession (Snedden & Warner, 1927, pp. 7-8). Warner identifies the same four curricular organizers: manufacturing, construction, communication, and transportation, for the study of industrial arts. The research and development done by Warner and his associates reflect the technology of post-World War II. Interestingly enough, Warner's selection of his four curricular organizers was based on his continuous monitoring of census and economic data, beginning in 1925 (p. 5). Warner's curriculum was designed to be taught in what he termed a "laboratory of industries" (Department of Practical Arts & Vocational Education, 1930).

Wilber (1948) looked at industrial arts' role in general education. He defined industrial arts as:

> those phases of general education which deal with industry--its organization, materials, occupations, processes, and products--and with problems resulting from the industrial and technological nature of society. (p. 2)

In organizing his three objectives of general education, Wilber used the term industrial as a curricular organizer for transmitting a way of life. The implications for industrial arts stated by Wilber reflected the thinking of Warner.

Olson (1963), a student of Warner, classified industrial arts' subject matter through an industries analysis. His analysis identified eight categories of industries: manufacturing, construction, power, transportation, electronics, research, services, and management (p. 95).

The numerous curriculum projects of the 1960's influenced by Sputnik and the federal and private legislation that followed emphasized industrial arts' curriculum to be organized with an industrial base. The Industrial Arts Curriculum Project (1966) organized the study of industrial technology under two major organizers: manufacturing and construction. Likewise, curriculum projects such as the American Industry Project (1968), the Functions of Industry (1962), and Georgia Plan (1967), the Industriology Project (1968), and the Orchestrated Systems Approach (1968) all reflect similar industrial curricular organization of Warner.

The Jackson's Mill Industrial Arts Curriculum Symposium (1981) adopted construction, manufacturing, communication, and transportation as their curricular organizers. The Technical Foundation of America study and guide, *Industry and Technology: A Guide for Curriculum Designers, Implementation, and Teachers* (1984), also used the same four industrial curriculum organizers.

LaPorte (1986) identified six challenges that the technology education profession must meet. Among these are that:

> A clear definition of technology education must be communicated to the various constituencies which are to be served, the current major organizers of production, communication, and transportation must be discarded or revised because they are inclusive of industrial technology, not technology *in toto*, the relationship of technology education to related programs must be established and clarified, and the advantage of teaching the 'how to' aspects of technology must be irrefutably defended and delineated. (1986, pp. 71-72)

To date, there has not been a study conducted to determine the appropriate curricular organizers for the study of technology relative to its future nature and how technology will be learned. Therefore, it is necessary to examine this crucial issue.

Statement of the Problem

The problem of this study stems from the vast misunderstanding or broad interpretations as to what technology is and what the study of technology encompasses. Therefore, the purpose of this study is to identify key descriptors of a definition of technology and the appropriate curricular organizers for the study of technology.

Research Questions

The research questions in this study included:

1. Looking into the future, what will be the key descriptors of a definition of technology?

2. Looking into the future, what will be the appropriate curricular organizers for the study of technology?

Significance of the Study

Herbert Spencer wrote "before there can be a rational curriculum, we must settle which things concern us most to know; we must determine the relative value of knowledge" (1911, p. 7). Therefore, one must ask the question, what is the true value and purpose of education? Simply stated, it is to provide youth with a wellspring of skills and abilities to apply knowledge efficiently. More specific, the synoptic study of technology provides a synergistic approach to all school disciplines to accomplish this mission.

Dugger called for the need to research and identify appropriate curricular organizers to reflect the study of technology (1985, p. 2). Maley, in his keynote address at Technology Symposium VII, agreed with Dugger by challenging the technology profession with a three part curriculum, involving the content, the individual (student), and the society. Maley stated that curriculum has been "largely content taxonomies or content delineations with little concern for the student and their internal goals, as well as the human quality needs of society" (1985, p. 10). In his speech, Maley also called for a concensus on an operational definition for technology education (1985, p. 3).

Squier, in a paper presented at the Mississippi Valley Industrial Teacher Education Conference in 1985, challenged the members that the present curricular organizers for the study of technology were delimiting and that they did not appropriately represent the study of technology. In this paper, Squier stated that skill development is not the primary purpose of technology education and that technology education should not focus upon technical content. "The real focus, however, must be upon the knowledge, skills, and attitudes essential for all students to live and interact in the artificial, human-made world"

(1985, pp. 6-7). Problem-solving and concept development through a holistic approach are the key components of technology education.

Numerous excellence in education reports issued in recent years have called for drastic educational reform. Most reports agree that three subjects are essential for all youth's education; science, mathematics, and technology education. However, their reference to technology education is not one of the vocational curriculum, but rather a general education curriculum. The reports, for the most part, recommend that technology education must be holistic in nature, utilizing a problem-solving and critical thinking approach to integrate and apply other discipline content.

The National Science Foundation Report (1983) stated that "technology topics need to be integrated into the present curriculum. This includes science and mathematics classes, industrial arts, social studies and the language arts, and art and music" (p. 75). Boyer, in the Carnegie Foundation for the Advancement of Teaching Report, *High School: A Report on Secondary Education in America* (1983) cited the need for technology education that would lead to a more technologically literate citizenry (p. 11).

Shane (1977) identified twenty-eight cardinal premises for educational change that stressed the need to organize curriculum in a holistic, life-long process that fosters interdisciplinary problem-solving and critical thinking activities (pp. 59-68). The school of the future should embrace technology to encourage creativity, problem-solving, efficiency, and controlling the world (1981, pp. 351-356). Bell concurs with Shane when he outlines the need to reorganize curriculum to better learn "intellectual technology" (1973).

Truly, if technology education is to play a role in preparing a technologically literate citizenry, its curriculum organization must be studied to appropriately identify and gain consensus on the curriculum organizers for the study of technology and the definition for the field of study. It is, therefore, significant that this research study will accomplish this.

The Design of the Study

A three round Delphi Technique was used to conduct the research for the study. Seven panels, composed of five members each, were used for the three round Delphi. The panels included: (1) technology education professionals, (2) industrialists/business leaders, (3) futurists, (4) historians of technology, (5) anthropologists of technology, (6) philosophers of technology, and (7) philosophers of education. The first round Delphi was open-ended. The second round Delphi asked the experts to Q sort both the key descriptors of a definition of technology and the appropriate curricular organizers for the study of technology. The third round Delphi used a Q sort method for ranking both the key descriptors of a definition of technology and the appropriate curricular organizers for the study of technology.

A Thurstone Equal Appearing Interval Scale was used to assign a scale value to each item ranked in the Q sort. The results of each research question were ranked based on their scale value. Items reaching consensus of opinion were determined by those items whose scale value was equal to or greater than the 80th centile. Each round called for a ten day turn-a-round period once the expert received the instrument. To ensure this, a postcard was mailed to each expert as a reminder five days after the instrument for that round had been mailed. Two days after the deadline for a round, a follow-up telephone call was made to each expert whose instrument had not been received. The data was then analyzed.

Validation of the Procedure as Being Representative of the Delphi Technique

To ensure that the Delphi procedure established was valid and would yield significant results, the researcher used the following method.

1. A review of the literature was conducted to understand the educational applications of the Delphi Technique and how it could be best used in this study.

2. The Delphi procedure was established by the researcher's review of the literature and it was approved by a review committee.

3. The Delphi instrument was received by a panel of Virginia Tech faculty members to ensure clarity and to confirm that the right questions were being asked of the panel of experts.

Selection of the Panel of Experts

From the review of literature and recommendations from the people interviewed, the researcher developed a list of experts for each Delphi panel. The researcher then identified an expert in each category to review the list for that panel and to recommend ten experts from the list of other they felt more appropriate. Following this step, the experts were selected for each panel by a random draw of names from a hat. The first five names drawn for each panel served as the panel of experts for that group, the other five names served as alternates. The first five names drawn for each panel served as the panel of experts for that group, the other five names served as alternates. Each of the panelists selected were contacted by telephone to ask if they would be willing to serve as a panelist for the study. If a selected expert could not serve, the first alternate was called as a replacement, and so on until five experts represented each panel.

If, for some reason, a panelist decided not to continue once the study had begun, the panelist had to state specific reasons for doing so in writing. Another expert was selected at random to replace the panelist, provided the first round had not been completed. After the first round, panelists were not replaced.

Conduct of the Research

The Delphi procedure used in this study parallels the research of Helmer (1963, 1967), Dakley (1967), Gordon and Helmer (1964), Linstone and Turoff (1973), and Brooks (1979). A review of doctoral dissertations on education that have used the Delphi Technique was also conducted. They were consistent with the research of the aforementioned experts. The research procedure for this study consisted of a three round Delphi to gain consensus of opinion on the two key research questions: (1) looking into the future, what will be the key descriptors of a definition of technology and (2) looking into the future, what will be the appropriate curricular organizers for the study of technology?

For each round, measures were taken to prevent attrition and to increase the response rate. The Delphi I was mailed to each panelist within one week after all experts agreed to serve on the jury. The second and third round instruments were also mailed to the panelists within one week after all responses had been received from the previous round. A follow-up postcard was sent to all experts on the fifth day after the Delphi instrument for that round was mailed. A follow-up telephone call was conducted to each panelist whose instrument had not been received two days after the deadline for that round.

The first round served to gain a general consensus of opinion of all panelists. The first round was open-ended. This technique was supported by the basic Delphi procedure outlined for the first round by Pfieffer (1968). The Delphi I gave a description of the purpose and requirements of the first round instrument. An example was provided for clarity.

Each expert was asked to answer the two research questions in brief and concise statements or lists. Once all responses were received, they were compiled under their appropriate research question. All responses were reviewed to avoid redundant responses. Following this, all response items were retyped on Q sort cards as outlined in Thurstone and Chave's equal appearing interval scale procedure. This Q sort procedure then became the Delphi II instrument.

The Delphi II instrument was sent to each panel of experts. The instrument provided each expert with a description of the purpose and requirements of the second round instrument. An example was provided for clarity. For each research question, each panelist was asked to Q sort the items under each question, according to Thurstone and Chave's equal appearing interval scale procedure. A Thurstone and Chave equal appearing interval continuum was provided to aid the experts in sorting the items. The continuum consisted of 11 interval cards, ranging from card A to K. The A card represented unfavorable, the F card represented neutral, and the K card represented favorable. For both research questions, statements compiled from Delphi I were placed on a separate card. The panelist was then asked to sort the statements along the A-K continuum, based on the increasing or decreasing degree of favorableness or unfavorableness.

Once all responses were received, they were reviewed to eliminate responses that were carelessly done or for those panelists who misinterpreted the instructions. A criterion was used that eliminated responses that placed 30 or more statements on any one card. A scale and Q value were calculated for each item, according to Thurstone and Chave's equal appearing interval scale procedure.

Results

The Delphi I instrument was mailed to all 35 experts. Twenty-five experts or 71.4 percent completed the instrument, with 23 of the 25 experts returning the instrument within the required time frame. The other two participants returned their Delphi I instrument within five days of the original deadline. The attrition was due to changes in already busy work schedules of the 10 experts who dropped out. All 25 remaining experts completed the other two Delphi instruments. The participant breakdown is summarized in Table 1.

Table 1

Summary Table - Participant Breakdown

Panel	Delphi I	Delphi II	Delphi III
Technology educators	5	5	5
Philosophers of education	5	2	2
Philosophers of technology	5	3	2
Historians of technology	5	4	4
Anthropologists of technology	5	4	4
Futurists	5	4	4
Industrialists/Business leaders	5	4	4
Total	35	26	25

After a content analysis was completed on the Delphi I instrument, Q sort cards were developed for each research question. The research question relative to key descriptors of a definition for technology consisted of 133 cards, while the research question relative to the appropriate curricular organizers for the study of technology contained 88 cards. The same cards were used for both the Delphi II or III instruments, except the Delphi III instrument included the scale value for that item on the card.

It should be noted that the 80th centile was the point at which consensus was reached on an item for each research question. Only the consensus items are listed in this report. It is also important to understand that the higher the Q value for an item the greater the panelists differed in agreeing on an item. The consensus cutoff point for the key descriptors of a definition for technology was 9.27, while the 80th centile scale value for the curricular organizers for the study of technology was 9.68.

Key Descriptors of a Definition for Technology

Fourteen items reached a consensus of opinion relative to what will be the key descriptors of a definition for technology from the panels of experts (Table 2). It appeared from the data that the definition will be described in terms of statements that emphasize concepts and processes. The data also appeared to indicate a strong emphasis on the relationships between humans, their capabilities and potential as they interface with the social, economic, political and environmental impacts of their culture and their future.

According to the data, there tended to be greater emphasis on innovation invention, creativity and problem solving than on hardware and software. It also appeared from the data that the definition for technology will be described in more holistic terms than narrowly focused to a specific type of technology.

The technology educators viewed the item creative as the most important descriptor of a definition for technology, followed by invention and innovation respectively. It appeared from the data a strong emphasis on a holistic description of technology. The data indicated relatively strong support for a problem solving, a decision making, and a process approach. Little emphasis was placed on narrowly focused descriptors.

The data appeared to indicate that philosophers of education placed a greater emphasis on describing technology relative to the human and how technology affects the human. Based on the data, they described technology as applied knowledge, technology as a means for maximizing human potential, technology used to solve problems and create opportunities, and technology as a process. It appeared from the data that philosophers of education were less likely to describe technology as closely related to science or engineering, as a class of materials, or the system that determines population size or density.

It appeared from the data that the philosophers of technology had a more difficult time reaching a consensus of opinion on the items for the key descriptors of a definition for technology than did the other panels. However, like the philosophers of education they tended to be concerned with describing technology in the terms of its effects on the advancement of humans and how its helps humans function in the environment by extending their capabilities.

Based on the data, the historians of technology were more concerned with describing technology skills and techniques that help humans manipulate their environment. It appeared from the data that historians of technology believed that technology is a process and has a definite body of knowledge. The data also tended to indicate that they were less inclined to describe technology as uncovering science, or that system that determines population size and density.

Like the technology educators, the data tended to show that anthropologists of technology placed greater emphasis on innovation, extension of human potential, invention and creative among their key descriptors of a definition for technology. The data also appeared to indicate that they described technology as a core component to all indigenous cultural systems. Conversely, the data tended to indicate that anthropologists of technology were less likely to describe technology as technology management, a class of materials, or as advancing civilization.

The data appeared to show that futurists, like other panels, described technology in the terms of innovation, creative, invention, and a body of knowledge. However, unlike most groups, futurists tended to place a high value on the application of tools as a key descriptor of a definition for technology. The data also tended to indicate that futurists were less inclined to describe technology in a narrow scope.

Unlike other panels, the industrialists/business leaders tended to place a high value on describing technology as an approach to solving problems and creating opportunities. The data also suggested that they contend that technology extends human potential and human capabilities. The data also appeared to indicate that industrialists/business leaders were less likely to support the notion that technology should be described as a class of materials or as skills or technological products.

Curricular Organizers for the Study of Technology

Collectively, the data tended to indicate that the curricular organizers were based on concepts and methods, instead of content (Table 3). The data showed that there was also almost total consensus on problem solving as the most important curricular organizer. Four out of seven groups ranked problem solving as the most appropriate curricular organizer. The data also appeared to indicate that process organizers that are composed of the integration of problem solving and creativity with systems, enterprise, and inventions, values in technology, the process of technology, design and innovation, and research and development were also highly appropriate curricular organizers for the study of technology. Although awareness of implications and potential of technology also reached a consensus of opinion by the panelists, it should be noted that it is subsumed under the aforementioned curricular organizers.

From a review of the data, technology educators believed the problem solving is the most favorable curricular organizer for the study of technology. The data also appeared to show that technology educators tended to agree on all the curricular organizers that gained a consensus of opinion by the panelists. The data tended to indicate that technology educators were less inclined to support content organizers as appropriate curricular organizers for the study of technology.

Table 2
Delphi III
Key Descriptors of a Definition for Technology - Cumulative

Item	**Scale Value**	**Q Value**
Innovation	10.42*	2.33
Invention	10.08*	2.30
Creative	10.06*	1.89
Extends human capabilities - physical - social - intellectual	9.91*	1.93
A process - change - individual - corporate - design - creative - systematic	9.88*	2.03
Extension of human potential	9.81*	2.36
Problem solving	9.75*	2.66
Purposeful, human manipulation of the material world	9.71*	2.36
Closely linked to science but not simply applied science	9.60*	3.09
Body of knowledge	9.55*	3.48
Used to solve problems and create opportunities	9.40*	2.26
Played an important role in the emergence of *Homo sapiens*	9.33*	3.39
A system of tools, knowledge, and behaviors associated with the exploitation of environments	9.33*	3.89
Has social, economic, political, and environmental impacts	9.29*	3.05

Relative to the philosophers of education, the data appeared to indicate that the study of technology were organized around concept and process organizers. It appeared from the data that they highly favored design and innovation as an appropriate curricular organizer for the study of technology. The data also tended to show that the philosophy of technology, the process of technology, and technology literacy elements were very favorable as appropriate curricular organizers. Again, the data indicated that the philosophers of education will tend not to favor specific content organizers as being appropriate curricular organizers for the study of technology.

Based on the data, it appears that the philosophers of technology were more inclined to organize the study of technology around ethical and social concepts. They tended to place a greater emphasis on the limits of technology, appropriate technology, the history of technology, ethical implications of technology, the social studies of technology, and the philosophy of technology as being very favorable curricular organizers for the study of technology. On the other hand, they tended to view organizing technology around work, leisure time and progression as less favorable.

The data appeared to indicate that historians of technology, like the philosophers of technology tended to organize the study of technology around social and ethical concepts. The data tended to indicate that they highly favored the history of technology, technology and organizational change as being very favorable curricular organizers for the study of technology. Conversely, the data appeared to show that historians of technology tended not to be willing to organize the study of technology as a content structure.

Like the technology educators, the data appeared to show that anthropologists of technology viewed problem solving and process organizers as the most favorable curricular organizers for the study of technology. Values in technology, the theory of technology, the elements of technology, and research and development also tended to be highly favorable, according to the data. The data tended to indicate that anthropologists of technology were less likely to organize the study of technology around content.

The data appeared to show that futurists agree with the majority that problem solving will be the most favorable curricular organizer for the study of technology. However, unlike other panels, the futurists highly favored physical technologies and the systems of technology as being very favorable curricular organizers. Like the other panels, the data tended to show the futurists will be less inclined to organize the study of technology as content.

The data tend to indicate that industrialists/business leaders will agree with the technology educators and the anthropologists of technology that problem solving and process organizers will be the most favorable curricular organizers for the study of technology. Like all other groups, the data appear to support the notion that industrialists/business leaders will be less likely to organize the study of technology as content.

Conclusion

The findings of this study provide an excellent foundation for organizing the study of technology. The consensus items for each research question parallel each other in context and both support holistic and lifelong learning theory of Shane (1977), Woodruff (1973), and others. This is a conceptual approach to the study of technology, not a content approach. Therefore, the curriculum is driven by methodology and concepts, instead of content that may not be relevant in the future. This approach provides a means to apply knowledge in a synoptic means through the integration of school discipline. However, at the same time the organization structure allows for the curriculum to maintain its own identity.

Table 3
Delphi III
Curriculum Organizers for the Study of Technology - Cumulative

Item	Scale Value	Q Value
Problem solving	10.76*	1.50
Process organizers - creativity - enterprise - systems - inventions - problem solving	10.61*	3.30
Values in technology	10.00*	2.13
The process of technology	9.91*	2.25
Design and innovation	9.80*	2.26
Research and development	9.76*	2.22
Awareness of implications and potential of technology - health - food - communication - production - control	9.69*	2.55

The literature gives strong support for the definition of technology to be studied. LaPorte (1986), Maley, (1985), among others have called for a consensus on an operational definition of technology. Shane (1986) discussed education in a microelectronic age that has direct impliactions to the need of an operational definition to help education through this new age.

Educational reform reports have also impacted on the need to study and develop an operational definition for technology. Boyer (1983) called for all students to study technology, not narrowly focused, but holistic in nature. The report, *Educating Americans for the 21st Century* also emphasizes the study of technology from a broad context.

As with any curriculum, the organization for the curriculum must parallel the definition for that curriculum. Such is true with the study of technology. As supported by Shane (1986), Naisbitt (1982), and other futurists, one can only speculate on what the future will be. Therefore, it is important that the curriculum be organized in such a fashion that will take into account preparing students to be able to analyze the unknown variables and solve the problems of the future. This notion is supported by Shane (1986) and Glatthorn (1987) in discussing the curriculum of tomorrow.

Again, technology educators, like LaPorte (1986), Dugger (1985), and Maley (1985) have called for the study of technology to be reorganized to reflect a more holistic approach to its study. More specific, Squier (1985) emphasized the need to use a problem solving and critical thinking approach to the study of technology. This approach is the predominant approach for the study of technology in the United Kingdom, the Netherlands, and Australia, just to mention a few countries.

Interestingly, the data collected in this study support the aforementioned beliefs relative to the need to study a definition for technology and the appropriate curricular organizers. The data show a strong emphasis for describing the definition of technology in holistic terms. Likewise, the data place strong support for organizing the study of technology around concepts and methods. Special emphasis should be placed on problem solving and process organizers that integrate creativity and problem solving through a systems approach. It is the researcher's belief that the literature and the data collected and analyzed in this study lend impetus to moving toward the implementation of the key descriptors of a definition for technology and the appropriate curricular organizers for the study of technology that gained consensus in this study. Therefore, the following recommendations should be considered in this implementation process.

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An Instructional Model for Electronics Technology in the Republic of China

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Introduction

Electronics technology has a great impact on our society. Christopher Evans (1979), Joseph Daken (1981), Frederick Williams (1983), Friedrichs and Schaft (1983), and Feigenbaum and McCorduck (1984) have dealt with the issue of the impact of electronics technology either directly or indirectly on society. Evans deals with the microelectronics millennium; Daken focuses on how electronics changes not only how we live, but ultimately how we think by forcing the development of a new age of logic; Williams studies the communication revolution and stresses that electronics technology plays a major role in it; Friedrichs and Schaft discuss microelectronics and society; Feigenbaum and McCorduck focus on the fifth generation computer which will be greatly influenced by electronics technology.

It is important to educate the public to better understand the tremendous influence of electronics upon our daily lives. It is also necessary to establish electronics technology programs for vocational schools. Taiwan, the Republic of China, has been exporting many electronic products such as radios, televisions, and accessories for microcomputers. Leaders in the Taiwan educational system are aware of the fact that it is important to provide an electronics technology program for both general and vocational education. Currently, an electronics technology curriculum is included in the junior and senior high schools, technical colleges and teachers' colleges. Today, electronics technology has become an important subject both in general and vocational education in the Republic of China.

When an instructional model for electronics technology is considered, the first step is to answer the question: why an instructional model for electronics technology is necessary?

A Subject Has Its Own Characteristics

Electronics technology is complex and changing in nature.

> Each area of knowledge--a subject or a discipline--has at least two main characteristics: it has its own fund of acquired information and a specialized method of inquiry, or a strategy of acquiring that knowledge. (Taba, 1962, p. 172)

It is necessary to emphasize here that electronics technology is a subset of technology.

> The study of technology has been approached too frequently by studying the parts without reference to the whole. However, as is the case with human beings, the sum is greater than the parts. (DeVore, 1980, p. 243)

It is important to illustrate here that technology is one of the domains of human knowledge. First of all, it is necessary to think of how technology should be thought of today. Von Bertalanffy (1972) states that:

> Technology has been led to think not in terms of single machines but in those of systems in the present day. An automobile, or radio receiver was within the competence of the engineer trained in the respective specialty. But when it comes to ballistic missiles or space vehicles, they have to be assembled from components originating in heterogeneous technologies, mechanical, electronics, chemical, etc.; the relation of man and machine comes into play; and innumerable financial, economic, social and political problems are thrown into bargain. Again, air or even automobile traffic are not just a matter of the number of vehicles in operation, but are systems to be planned or arranged. Innumerable problems are arising in production, commerce and armaments. (pp. 3-4)

Human Knowledge

This paper attempts to identify the context of electronics technology within the broader framework of human knowledge. Man's knowledge has been digested and accumulated from generation to generation. To obtain efficiency in education, the classification of man's knowledge is necessary. Towers, Lux, and Ray (1966) described the need to structure knowledge into domains:

> Man's accumulated knowledge, increasing at an accelerating rate, is vast in scope and heterogenerous in nature. It is not economically feasible to deal with this amorphous mass without structuring it into logical divisions. Thus, for various reasons, knowledge has been subdivided into more manageable divisions which are functional, for one reason or another. It may be postulated that one such division would include man's knowledge of how to do things efficiently, without such knowledge, the world of work would be chaotic. (p. 1)

The knowledge of doing things efficiently is called technology. People have sought new knowledge and efficient ways of doing things since beginning of humankind. The truth is that doing things efficiently is at the very heart of human existence and has been central to human history. To take a view point based on historical review, it is found that man is a tool-maker; man is an environment-changer; man is a power machine developer; man is a control-machine developer; and man is a social animal. The writer summarizes that:

Human beings use their inherent tools--hands, and mental tools--senses and brain, to create power tools for matter and energy conversion and control tools for information management. With inherent tools, man made power and control tools, humans are able to adapt to or change their natural or social environment.

Man's civilization progresses in a spiral trajectory based on this fundamental pattern. No one questions the importance of technology in our contemporary civilization, in which technologists have been led to think not in terms of single machines but in terms of systems. Therefore, knowledge of the nature of technology and its relationship to other ways of describing and understanding human experience is needed as background. To integrate other knowledge into the field of technology is important.

Technology and Science

Though technology and science are not the same, their relationship is vital. If the relationship between technology and science could be clarified, a more adequate understanding of technology will be attained.

If science is a method for the description, creation and understanding of human experience, technology may be defined as human activity directed toward the satisfaction of human needs (real or imagined) by the more effective use of man's environment.

> It is important to note the obvious fact that technology is older than science. It is treated thus as obvious, since all the records of early man indicate clearly that he created tools and evidently used them long before he attempted any systematic account of the meaning of his activities. The only thing we can say with some assurance is that technology emerged before science, simply because man had to overcome the leisure to indulge his curiosity about the world in an intellectual sense. (Lindsay, 1962, p. 212)

Technology and Humanities

The story of technology is the story of man's ceaseless striving to extract what he calls a better living out of his surroundings, and the tale includes the invention of countless gadgets to make life at once more comfortable and more exciting. But does this means we shall all live "happily" ever after? It is important to point out that the role for value judgments is considered a part of the humanities. Humanities relate to varying sets of beliefs, values, and norms and are very culture related. Technology is said to be concerned principally with tools and machines, while the humanities deal with values. Technology does not pretend to tell us how to lead happy lives. It merely provides the tools necessary for civilization. It has left philosophers and other wise men to answer the fundamental questions so crucial for the behavior and fate of the individual. While modern technology tends too make the lives of people more materialistic in their attitude toward life, the challenge really comes from the continual adjustment required by all the new technological experiences being forced on society.

Technology and Formal Knowledge

> The disciplines without formal knowledge serve as tools which are to order all knowledge. . ..Mathematics and logic are examples of fundamental disciplines. (Tower,

Lux, & Ray, 1966, p. 9)

Mathematics plays a role of language in technology. In mathematics the symbols initially have no meaning except in their relation to each other and the various operations which they represent. The symbols obey a small number of relational rules, through which human beings can represent a wide variety of phenomena. Merely the clever identification of symbols can contribute to the action of technology. It is indicated that, mathematical and logical symbolism are increasingly providing technology with a more efficient means of communication.

The Complexity of Technology

The development of complex technology itself should be regarded as an important subject in the study of technology, as well as providing a valuable source of instruction.

There are many approaches to study the development of technology. Alvin Toffler (1981) cites three waves of change occurring of civilization and these waves also relate to technology. The first wave of change was unleashed ten thousand years ago by the invention of agriculture. The second wave of change was touched off by the industrial revolution. The third wave of change speaks of a booming Space Age, Information Age, Electronic Era, or Global Village (p. 9).

DeVore identifies the development stage according to a time dimension. DeVore's stages are: Modern Craft (1000-1784), Machine Age (1785-1869), Power Age (1870-1952), Cybernetic and Automatic Age (1953-present) (DeVore, 1980, p. 54).

The complexity of technology is parallel with the evolution of technology. What the levels of complexity should suggest is a gradual progression, beginning with simple hand or muscle driven tools moving upward through ever increasing levels of advanced technology. The writer suggests that from an illustrative viewpoint an analogy can be given to show how the evolution of technology can be represented in terms of human functions. It progressed from the invention of hand (neuro-motor or muscle driven) tools, to sensory (automotive) tools to brain-like (intellectual) tools. From this we can develop a good teaching model to explain the development of technology to students. The different levels of technological complexity can be represented in terms of human functions. These also form the fundamental spiral trajectory of technological evolution. This study affirms that all instruction is a spiral process which is based on a fundamental pattern that has a certain sequence.

1. Hand tools (muscle driven or neuromotor tools)
2. Sensory tools (automotive tools)
3. Brain tools (intellectual or automathematical tools)

Thus, the complexity of technology can be illustrated as shown in Figure 1.

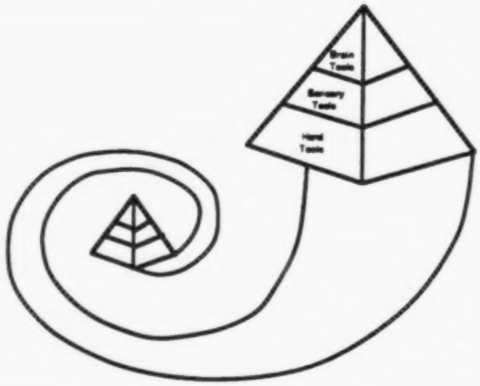

Figure1. Complexity of Technology in Terms of Human Organisms

Instruction is the process of arranging human, temporal, material, and spatial resources with the intention of facilitating one's own learning or the learning of others (Belland, 1976). From this definition it is obvious that instruction at least:

1. involves man, and
2. is concerned with environment.

The previous discussion about the level of technological complexity provides information about what should be an appropriate environment for the instruction for technology. However, instruction involves man and human aspects are another factor influencing technology instruction. DeVore (1980, pp. 223-224) explains that being humankind we are intimately related in the on-going process of life. Man's physical and mental characteristics related to technology result from this relationship. The humanly inherent tools are the hands, senses, and the brain, therefore the fact that hand tools and power machines were invented indicates that human hands provide both matter-energy transformation and information control. Control machines are invented for extending man's senses and brain. For the purposes of technology instruction, this study states an alternative way to express the evolution of technology (Figure 2).

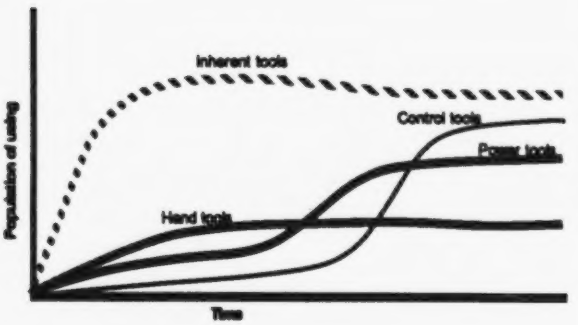

Figure 2. An Alternative Way to Express the Evolution of Technology.

The most important concepts in this figure are: The way in which the use of inherent tools dominates the other tools (machines) throughout the human civilization. The number of control machines is increasing at an explosive rate. The evolution of technology is continuous not revolutionary in nature. In other words, it is analog rather than digital. These concepts can be summarized, by saying, even in a complex technology instruction unit, inherent tools are also required and these will dominate others. Because control machines are increasingly popular, the principle of continuity in learning activities is important for the instruction of technology.

Electronics Technology

> To understand the field of electronics technology, the relationship of electricity to electronics must be defined and clearly understood (Inaba, 1970, p. 73).

From the definitions of the *Encyclopedia American* (1980, p. 134), and the *World Book Encyclopedia* (1986, p. 146), this study defines related terms as follows:

- Electricity is the study of how electrical charges are produced and used to provide electrical energy to do work.
- Electronics is the study of how electrons are controlled to carry intelligent signals for mankind through electronic products.
- Electronics technology is the science of studying efficient action and practicing the ways electrons are controlled to carry intelligent signals for mankind through electronic products.

According to these definitions, the term "electronics technology" refers to that part of the total field of electronics which is concerned with the use of electrons. "Carrying intelligence signals" relates to communication and information. Communication technology is identified here for two reasons. First, communication technology largely overlaps electronics technology in today's world. Communication technology includes such things as telecommunications, radio waves and radio telegraphics, which has led to the birth of the field of electronics technology. In turn, this was destined to affect the life of man as he had never imagined possible. Second, the history of communication is also a study of technology. Speech and hearing form a relatively sophisticated mode of human communication.

In addition, communication systems are widely discussed in many fields. Firstly, it runs the gamut of the electricity and electronics field. Secondly, it is dealt with in the field of instruction. Thirdly, it has become an important concept in General Systems Theory.

A communication system conveys information from its source to a destination. Figure 3 is a typical simple model. First, it is explained from the viewpoint of electronics, and elaborated on in the field of instruction, then compared with a living system, and then one kind of general curriculum systems theory.

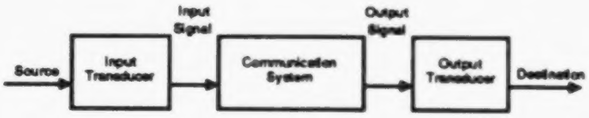

Figure 3. A Simple Communication System

Few message sources are inherently electrical, consequently, most communication systems have input and output transducers. The input transducer converts the message to an electrical signal, say a voltage or current, and another transducer at the destination converts the output signal to the desired message form. For example, the transducer in a voice communication system could be a microphone as the input and a loudspeaker as the output. The communication system block in Figure 3 is given further detail in block diagram and can be expressed by Figure 4.

The transmitter processes the input signal to produce a transmitted signal suited to the characteristics of the transmission channel. The channel is the electrical medium that bridges the distance from source to destination. The receiver operates on the

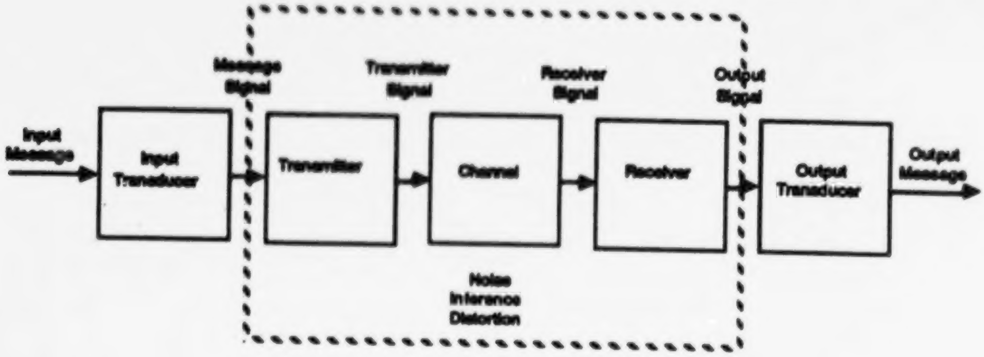
Input Message
Input Transducer
Message Signal
Transmitter
Transmitter Signal
Channel
Receiver Signal
Receiver
Output Signal
Output Transducer
Output Message
Noise
Inference
Distortion

Figure 4. A Communication System

output signal from the channel in preparation for delivery to the transducer at the destination.

In electronic communication, signal processing for transmission always includes modulation or encoding. Modulation and encoding are operations performed at the transmitter to achieve efficient and reliable information transmission.

On the other hand, receiver operation includes demodulation and decoding to reverse the signal-processing performed at the transmitter.

Figure 5 is a feedback connection popular in electronic circuits.

The term feedback is increasingly used in many fields.

> The term feedback means that two channels exist, carrying information, such that channel B loops back from the output to the input of channel A and transmits some portion of the signals emitted by channel A. (Miller, 1978, p. 36)

There must be feedback since that man is a living system. A living system is self-regulating because input not only affects output, but output often adjusts input. The result is that the system adapts homostatically to its environment (Miller, 1978; Asimov, 1972; & Phenix, 1964).

Feedback system has been increasingly used in the field of curriculum. Jackson's Mill used a feedback system as a universal system to express industrial arts curriculum construction (Figure 6).

This section integrates the communication technology, electronics technology and feedback system to form a general theory about a living system. This in truth contributes to the instruction of electronics technology.

Computing is the technology that derives from all other technologies (Feigenbaum & McCorduck, 1984, p. xvii), so whenever there is talk about electronics technology, the solution of the computer is mentioned. Most people label the first four generations of computers, each based on its central technology, in the following ways:

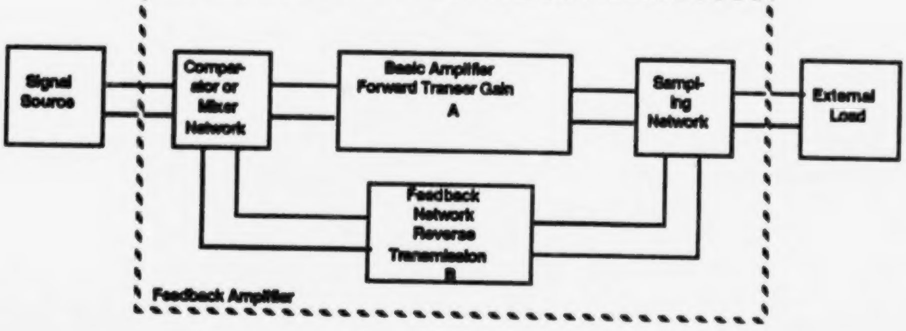
Signal Source
Comparator or Mixer Network
Basic Amplifier
Forward Transfer Gain
A
Sampling Network
External Load
Feedback Network
Reverse Transmission
B
Feedback Amplifier

Figure 5. An Electronic Feedback Circuit

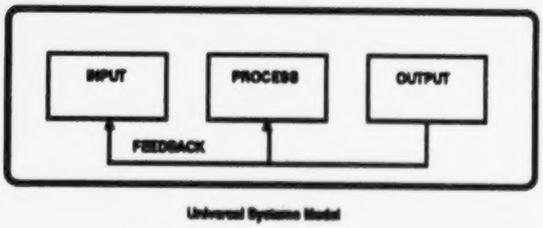
INPUT
PROCESS
OUTPUT
FEEDBACK
Universal Systems Model

Figure 6. A Universal System

1. electronic-vacuum tubes computers,
2. transisterized computers,
3. integrated circuit computers, and
4. very large-scale integrated (VLSI) computers.

This clearly indicates that the progress from electronic-vacuum tubes to VLSI is representative of the evolution of electronics technology.

The fifth generation will stand not only because of its technology, but also because it is conceptually and functionally different from the first four generations with which the world is familiar. These new machines will be known as Knowledge Information Processing System (KIPS). This term is extremely important. It signals that shift from mere data processing, which is the way present-day computers function, to an intelligent processing of knowledge. These new machines are to be specifically designed for artificial intelligence functions. It can be summarized by saying that KIPS are specially designed to do symbolic manipulation and symbolic reasoning (Feigenbaum, 1984, p. 15).

> There is no clear definition for artificial intelligence. However, the most widely accepted is Minsky's (Yazdani, 1984, p. 9).

Artificial intelligence is the science of making machines do things that would require intelligence if done by men.

Yazdani states that:

> It has identified three distinctions of AI resulting from different motivations or backgrounds. In order to see the point, consider a class of objects which we would regard as intelligent, e.g. cats, dogs, people and Martians. Outside this class, we have such unintelligent things as tables, chairs, and currently, digital computers. (See Figure 8) Group 1 would answer the question by saying that "AI is about moving computers into the space above (advanced computer technology)". Group 2 would say "AI is simulating human behavior and cognitive processes on a computer (computational theories in psychology)". Group 3's answer would concern the study of the nature of the whole space of intelligent minds.
>
> As can be easily noted, each of the above three camps borders one of the three established areas of computer science, psychology and philosophy. (Yazdani, 1984, p. 9)

It is important to elaborate upon important concepts: First, before the computer was invented, humans handled symbols and numbers by themselves, with or without the abacus or calculators. Second, the first four generations of computers handled just numbers and the fifth generation will handle both symbols and numbers. Third, there are both symbols and numbers to be handled in human lives. Research and study are being focused on the development of a machine that can perform functions that are normally concerned with human intelligence, such as learning, adapting, reasoning, self-correction, automatic improvement.

It is interesting and necessary to point out here that:

> Man is not a machine and a machine is not a man, but as science and technology advance, man and machine seem to be becoming less and less distinguishable from each other. (Asimov, 1972, p. 838)

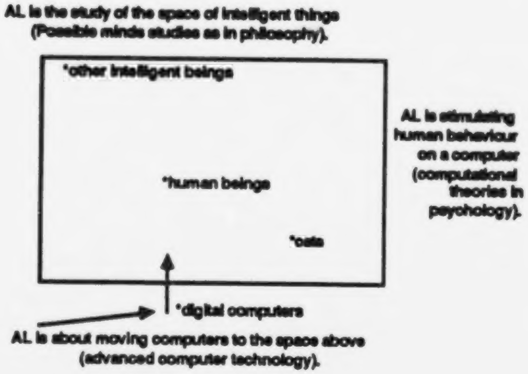
AI. is the study of the space of intelligent things
(Possible minds studies as in philosophy).
*other intelligent beings
AI. is stimulating human behaviour on a computer (computational theories in psychology).
*human beings
*cats
*digital computers
AI. is about moving computers to the space above
(advanced computer technology).

Figure 7. Artificial Intelligence Definition

The study of computers and related techniques is to supplement the intellectual capabilities of man.

As man has invented and used tools to increase his physical powers, he now is beginning to use artificial intelligence to increase his mental powers. Judging from this discussion, it is necessary to emphasize that for electronics technology instruction, how to use inherent tools efficiently is most important.

Selected Concepts From I Ching

Why I Ching?

An electronics technology instructional model based on instructional theories and the context of electronics technology is incomplete because it fails to account for the cultural context in which the model will be applied. Adapting concepts from the Chinese culture and philosophy makes the model specifically relevant to the Republic of China. This is because the valuable cultural treasures are familiar and inherent to the Chinese. It is well known that "Confucianism" is the most influential of all to the Chinese culture and society. The most distinguishing feature of electronics technology is that it accumulated changes and continuously progressed. In order to learn this changing subject matter, it is important to remember a Confucian remark: "To learn with indefatigable zeal and diligence in teaching." Other than that, it may be very helpful to consider "the ways of change" for developing an electronics technology instructional model.

The following are the reasons to choose *I Ching* among so many Chinese heritages as the elaboration to contribute to the proposed model.

- *I Ching* influenced the philosophy of *Confucius* and therefore of the Chinese.
- *I Ching* is a book which uses a symbolic representation method that provides a symbolic means of reducing the complexity of knowledge.
- *I Ching* discusses "changes," so it is very suitable to the instruction of the ever-changing electronics technology.
- Electronics technology deals with two states, open and closed; a digital computer deals with binary numbers, 0 or 1, while *I Ching* deals with Yin and Yang. It shows that although the *I Ching* is an old book in Chinese literature, it's duality concept is in accordance with the most advanced technology or science.

The Concept of I

The world "I" means change. So *I Ching* is usually called in translation "The Book of Changes." The *I Ching* is the most important of the five *Confucian Classics* and has had an influence on even commonplace everyday life in China for more than two thousand and five hundred years.

The significance of the *I Ching* as a book of science lies in its logic system of mathematic symbols. This logic system is based on the symbols Yin (--) and Yang (   ). It is the same as the computer's use of zero (0) and one (1) for its principles.

Combination is made by putting together there lines either Yin (--) or Yang (   ) which are represented by zero (0) and one (1) respectively. The Eight Trigrams then are accorded a natural sequence of numbers. The numbers from 0 through 7 refer to three lines of the Trigram, making the "--" small weight from top to bottom. These can be expressed as Figure 8.

Figure 8. The comparison of Yin and Yang and Binary Number System.

Decimal Numbers	0	1	2	3	4	5	6	7
Binary Numbers	000001002003				004005006007			
Eight Trigrams	☷	☶	☵	☴	☳	☲	☱	☰

The bottom line has the most significant weight in a binary number system. The bottom lines of the four foregoing Trigrams numbered from 0 to 3 are disconnected lines (0). The bottom lines of the subsequent four Trigrams, 4 to 7, are Yang lines. The bottom lines determining the position of Trigrams are exhibited circularly. If the bottom lines are Yin, the Trigram is drawn back counter (clockwise upward), while bottom lines are Yang advanced forward clockwise upward, than obtaining the Eight Trigrams exhibited circularly as in Figure 9.

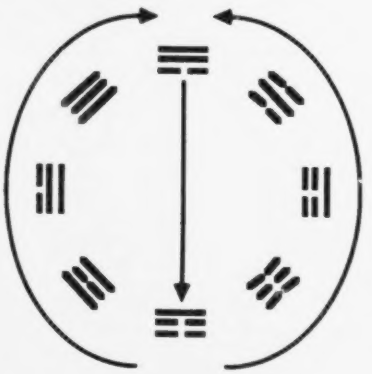

Figure 9. The Eight Trigrams

The sixty-four Hexagrams exhibited circularly are the same as Eight Trigrams being expanded. The circle which is considered as a whole can be divided by two parts of the right and left. The right part of the bottom Yin lines draw back counter (clockwise upward), while the left part of the bottom Yang lines advance forward (clockwise upward).

By putting together the upper (outer) Trigram in accordance with the succeeding natural sequence of (0): (1): (2): (3): (4): (5): (6): and (7) and adding each group in the same lower (inner) Eight Trigrams, the sixty-four Hexagrams are then formed as exhibited circularly in Figure 10.

Summarizing the major concepts for this subsection yield the following:

* Yin and Yang can be used as the same concept as "0" and "1".

* Trigrams and Hexagrams in *I Ching* represent both numbers and symbol in accordance with modern scientific concepts.

* Trigrams and Hexagrams are appropriate materials for teaching digital logic concepts in electronics technology in the R.O.C. everywhere.

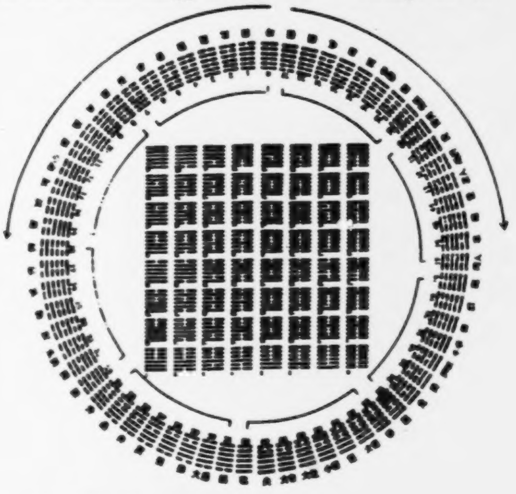

Figure 10. The Sixty-four Hexagrams

Three Attributes of I

The word "I" primarily means change, and the word "Ching" means cannonical text. Thus the *I Ching* has become known as *"The Book of Changes"*. In fact, the concept of I, it is said, has three meanings:

1. ease and simplicity,
2. transformation and changes, and
3. invaribility.

The first aspect of the concept of "I" is the ease and the simplicity. The "I" in the midst of complexities reveals simplicity. First of all, the *I Ching* asserts that the complex phenomena of the universe are simply derived from the T'ai chi (Supreme Ultimate). In the Hsi Tz'u Chuan (Great Commentary), there is the statement:

> . . . Therefore, in the system of the"I" there is the T'ai chi. This generate the Two Primary Forces. The Two Primary Forces generate the Four Images. The Four images generate the Eight Trigrams. (Sec.I. Ch 11)

This statement can be illustrated in Figure 11.

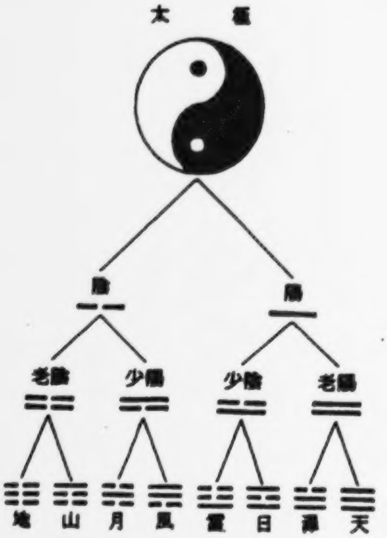

Figure 11. A Structure Model of I Ching.

The symbols and formulas represent the process of transforming what is simple and easy into what is complete and different The "Supreme Ultimate," T'ai chi, plays an important role in later Chinese natural philosophy.

The conditioning elements are further designated as an undivided line, while the conditioned element is represented by means of a divided line (--). These are the two polar primary forces later designated as Yang, the bright principle, and Yin, the dark. Then, through their combining, these arise the four images:

⚌ Old or great Yang　Old or great Yin ⚏
⚎ Young or little Yang　Young or little Yin ⚍

These correspond with the four seasons of the year. Through the addition of another line, there arise the Eight Trigrams:

Chien ☰ Tui ☱ Li ☲ Chen ☳

Sun ☴ Kian ☵ Ken ☶ Kun ☷

Originally, the Eight Trigrams may not have had any specific meanings attached to them, but later on they were elaborated upon so that each came to be sybolically representative of certain things or ideas.

The objects or attributes thus symbolized by the Eight Trigrams are made the constituents of the universe, which form the basis of a cosmological system. By combining any two of these Trigrams to form a diagram of six lines. A total of sixty-four combinations is obtained and are known as the sixty-four Hexagrams. The Eight Trigrams, together with the Sixty-four Hexagrams formed by their combinations, therefore, represent all the possible situations and mutations of creation, a universe in miniature. This offers a good illustration of the transformation from simplicity to complexity.

The "I" makes Ch'ien, or Creative (☰) and K'un or Receptive (☷) represent what is easy and simple: for only from what is easy and simple can there be "complex phenomena" and "great movement." As the Great Commentary puts it:

> The creative is known through the easy. The Receptive can do things through the simple. What is easy, is easy to know: what is simple, is easy to follow. . .By means of the easy and the simple we grasp the laws of the whole world. (Sec. I, CH. 1)
>
> The creative is the strongest of all things in the world. The expression of its nature is invariably the easy, in order thus to master the dangerous. The Receptive is the most devoted of all things in the world. The expression of its nature is invariably simple, in order thus to master the obstructive. (Sec. II, CH XII)

This idea of ease and simplicity attached to the "I" explains why the emphasis is often placed on ease and simplicity as the gateway to the pure province of the "I". Because of the concept that lies in the easy and simple, the *I Ching* can speak of the most confusion (Hsi Tz'u, Sec. 1. CH. 8).

The second aspect of the concept of "I" is the transformation and change. The word "I" primarily means change. In *I Ching*, it is said that: "All change and transformation are the result of movements." In the *I Ching* the word "I" is used interchangeably with the Tao. And Tao is simply defined as "the alternation of Yin (the shade/soft) and the Yang (the light/firm). Interaction of these two primal forces produces all kinds of movements and changes. In the Hsi T'zu, there are the following statements:

> As the firm and the yielding lines displace one another, change and transformation arise. (Sec. I. CH. 2)
>
> One Yin and one Yang constitute what is called Tao. That which is perpetuated by it is good. That which is completed by it is the essence: It possesses everything in complete abundance: this is its great field of action. It renews everything daily: this is its glorious power. (Sec. I, CH. 5)

The Tao, given here as the result of the unceasing movement of the Yin and Yang, corresponds to the Tao as a part of "the unceasing movement" and hence it is good. Everything transform and completes its power in the "unceasing movement." Because of this, the Tao achieves the great field of action, being abundant and daily renewed; indeed its achievement is achieved in daily renewal; that is, the unceasing movement going on in the world. As the Hsi Tz'u says:

> It is the great virtue of heaven and earth to bestow life. (Sec. I, CH 1)
>
> As begetter of all begetting it is called change. (Sec. I, CH 5)

The dark begets the light and the light begets the dark in ceaseless alternation, that to which all life owes its existence, is Tao with its law of change.

Moreover, the *I Ching* equates the Yang and the Yin with the Creative and the Receptive, the male and female principle, as physically represented by Heaven and Earth. As the Hsi Tz'u says:

> The creative and the Receptive are indeed the gateway to the Changes. The creative is the representative of light things and the receptive of dark things. In that the natures of the dark and the light are joined, the firm and the yielding received form. Thus give manifestation to the phenomena of Heaven and Earth and comprehension to the power of spiritual enlightment. (Sec. II, CH. 6)

Because of the union of the creative and receptive, all things come into existence, and hence come all changes and transformation. As is said in the Hsi Tz'u:

> There is an intermingling of the genial influence of Heaven and Earth, and transformation of all things proceeds abundantly. There is intercommunication of seed between male and female, and all creatures are born and transform. (Sec. II, CH. 5)

In the Hsi Tz'u there is another important passage:

> Therefore they called the closing of the gate the Receptive, and the opening of the gate the Creative. The alternation between closing and opening they called change. The going forward and backward without ceasing they called penetration. (Sec. I, CH. 11)

The content of the course of change is the unceasing process of "the opening and closing" symbolizing the primal forces--the Creative and the Receptive, the Yang and the Yin. Of these two primal forces, the one is vivid, the other docile, the one gives forth, the other receives; to the one all things owe their beginning, and to the other they all owe their birth. Thus in the Hsi Tz'u, there is the statement:

> There is Creative: "In a state of rest the creative is one, and in a state of motion it is straight; therefore it creates that which is great. The Receptive is closed in a state of rest, and in a state of motion it opens; therefore it creates that which is vast. (Sec. I, CH. 6)

Thus, the Creative and the Receptive complement each other and so the things in the universe ever change and transform.

The third aspect associated with the concept of I is invariability. The I in the midst of variability also reveals an element of invariability. The tings in the universe are always in a state of flux and change. In the T'uan, there are the following statements:

> When Heaven and Earth deliver themselves, thunder and rain set in. When thunder and rain set in the seed pods of all fruits, plants, and trees break open. The time of Deliverance is great indeed. (About Hsich, or Deliverance, the fortieth Hexagram)
>
> Heaven and Earth undergo their change, and the four seasons complete themselves thereby. (About Ko, or Revolution, the forth--ninth Hexgram.)

Nevertheless, these phenomenal changes all follow a constant order. The Tao of Heaven and earth is constant and unceasing. The sun and moon, pertaining to Heaven, can shine forever. The four seasons change and transform, and thus in their Tao, and the world is transformed to completion.

> When we see how there are constant, the nature of Heaven, Earth, and all things can be seen. (About Heng, or Duration, the thirty-second Hexagram.)

As a further expression of the "Tao of Heaven and Earth" which everything obeys, the following passage forms the Hsi Tz'u which be expressed:

> Good fortune and misfortune are constantly overcoming one another by an exact rule. The Tao of Heaven and Earth is constantly to manifest themselves. The Tao of the sun and moon is constantly to emit their light. All movements of the world are constantly subject to one and the same rule. (Sec. II. CH. 1)

All the passages quoted above clearly indicate that all things in the universe follow a definite order-- i.e. the Tao of Heaven and Earth--according to which they change and transform constantly. These passages also imply the ideas of the invariability as a necessary attribute of the concept of I.

In conclusion, the concepts of "I" has their important attributes: ease and simplicity, change and transformation, and invariability. These attributes should make clear three points.

- First, the process of transformation starts from the easy and the simple, and hence when one knows the cause of the easy and the simple, one can predict the causeof the complex and the difficult.
- Second, things in the universe are ever changing and changeable, but the underlying principles, for which the Tao can be employed, are constant and invariable.
- Although all the things in the universe are complex, forever changing, yet among the complexities simplicity can be found, among the changes something unchanging.

The Concepts Derived from I Ching for Instruction

There is a paper about curriculum from PHilip H. Phenix (1962).

> My thesis, briefly, is that all curriculum content should be drawn from the disciplines, or to put it another way, that only knowledge

> contained in the disciplines is appropriate to the curriculum. . . . (p. 273)

Phenix further defines that a discipline is knowledge organized for instruction (p. 273). Then he explains how to make knowledge instructive:

> . . .There are three fundamental features, all of which contribute to the availability of knowledge for instruction and thus provide measures for degree and quality of discipline. These three are:
>
> 1. analytic simplication,
> 2. synthetic coordination, and
> 3. dynamism. (p. 275)

Phenix explains that the prime essential for effective teaching is analytic simplification. All intelligibility rests upon a radical reduction in the multiplicity of impressions which impinge upon the senses and the imagination. Phenix continues to explain the second feature of a discipline which makes knowledge in it instructive, namely, synthetic coordination. Analysis is set an end in itself; it is the basis of synthesis. By synthesis is meant the construction of new whole, the coordination of elements into significant coherent structures. A discipline is a community of concepts. Just as human beings cannot thrive in isolation, but require the support of other persons in mutual association.

The third quality of knowledge in a discipline that Phenix dynamism. It is the power for leading on to further understanding. Phenix explains:

> A discipline is a living body of knowledge, containing within itself a principle of growth. Its concepts do not merely simplify and coordinate; they also invite further analysis and synthesis. A disciplinary contains a clue to discovery.

In the similar way as Phenix does, the writer advocates to fit the three attributes of I Ching into the field of instruction.

For educational purpose, the writer advocates that electronics technology should be able to be classified, ordered, and codified. If it is classified, then it becomes simplified and can be taught. If it is ordered, then it has a hierarchy and can be taught in a logical sequence. If it is codified, then it becomes flexible and suitable to different situation and interval. The classified, ordered, and codified electronics technology can be arranged and become a structured instruction. A structured instruction will help the learning of the student. What is a structure?

Chung Ying Cheng (1985) indicates that there are two forms of transformation in the I Ching: the transformation of things through the self-transformation of the creative source--the Tai-Chi; and the transformation of the interaction of things via their relative relationships in the totality of things (pp. 90-91). The first form of transformation can be called vertical transformation, and the second form of transformation can be called horizontal transformation. The transformation from the Tai-Chi to the sixty-four Hexagramatic situation is a matter of vertical transformation. The inter-relationship, interaction and mutual transformation among all the sixty-four Hexagrams is a matter of horizontal transformation. The vertical transformation illustrates how the totalities on different levels of ontological differentiation relate to each other and how they differentiate as well as integrate.

In the horizontal transformation, things are parallel on the same level. One thing may exist in meaning to a certain condition, but an other may not be relevant to the condition.

The writer's structural learning concept is that basic concepts can be extended to become learning blocks. Using these blocks many complex concepts can be developed. The model is shown in Figure 12. This structure does not mean that complex concepts will be fewer in number than basic concepts. On the contrary, complex concepts can be built almost infinitely.

An Instructional Model for Electronics Technology

Developing the Model

Electronics technology is changing, complex, and comprehensive in nature. The followings are the characteristics of electronics technology instruction which are identified from the findings of previous discussions:

- Electronics technology instruction should actualize some goals of total education for today's complex and changing world.
- Electronics technology can be classified, ordered, and coded in a flexible structure which is adequate for different levels and purposes of an electronics technology program.
- An adequate model is necessary for electronics technology instruction to carry out the learning objectives.

Because of the inevitability of change of electronics technology, some of the educational goals can be actualized by learning activities of electronics

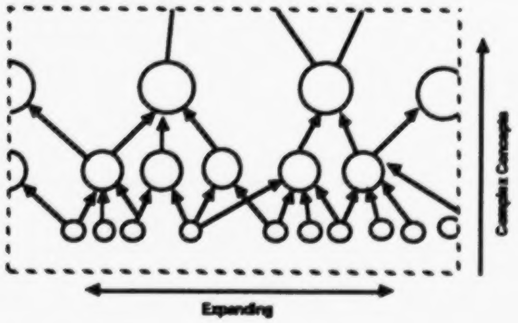

Figure 12. A Structural Concepts Model

technology. The following goals are selected from the goals which derived from ASCD (Brandt & Modrak, 1980, pp. 9-12).

- Bases actions and decisions on the knowledge that it is necessary to continue to learn throughout life because of the inevitability of change.
- Bases actions and decisions on an understanding that change is a natural process in society and one which increases exponentially.
- Works now for goals to be realized in the future.
- Entertains new perceptions of the world.
- Selects viable alternatives for actions in changing circumstances.

Because of the nature of complexity and comprehension of electronics technology, the following goals should be considered:

- Apply basic principles and concepts of the science, humanities and formal knowledge to interpret the nature, the process, and the issues of electronics technology.
- Generates a range of imaginative alternatives as stimuli.
- Entertains and values the imaginative alternatives of others.

It is necessary to develop the model in a flexible structure which can be adapted for different levels and purposes of an electronics technology program in order to have efficient instruction.

The Diagram of the Instruction Model

The following are the bases derived from the previous discussions for establishing the instructional model.

The writer advocates that learning is a spiral process, so we can assemble the concepts upon which we can build a number of complex concepts. These concepts are like the bricks in a wall or conversely them form an ever enlarging fanlike effect. In both models they are examples or endless construction both or ordered any yet uncontainable.

The writer extends these ideas to develop the following model for use in electronics technology instruction illustrated in Figure 13.

- This model can consist of a single block or the combination of many blocks as a more complex model following the writer's structure concept.
- *Motivation* is depending on learning content or learner's condition, and the Confucian remark--to learn with indefatigable zeal and diligence in teaching--is deeply rooted in Chinese mind that can be used for both the teachers and the students when learning electronics technology.
- *Doing* in this model is different from conducting an experiment. It is not used to prove a theory or a fact. It is used to learn simple skills, knowledge, or concepts which can be used to expand to more skills, knowledge, and concepts. The *doing* is for learning.
- *Expansion* is used to integrate the human knowledge into the field of electronics technology.
- *Conception* is important in this model for identifying some specifications which serve as outputs that can in turn serve as another input's specifications.
- Both input and output specifications contribute to the model. Only when a model has input and output specifications can it be connected to another model and become a structurable model connected to other models and become a unit in an even more expansive model.

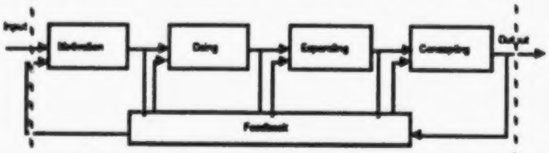

Figure 13. An Instructional Model for Electronics Technology

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"Jackson's Mill" and "Industry and Technology Education" Project Reports as a Guide for Organizing Content for Technology Education

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Technology educators face major challenges and opportunities as they convert industrial arts programs, with their tool skill emphasis, into technology education, with its technology literacy mission. A number of individuals and groups suggest that this transition is an educational imperative. A recent workshop sponsored by JETS (Junior Engineering Technical Society) on "Fundamentals in Precollege Technology Education" (1983) suggested "a foundation in technology be regarded as fundamental for all--not just the high-achiever. . .Every student deserves to be aware of the impact of technological advance, and be able to understand the underlying technology itself. . .Society must insure that an understanding of technology be a part of each student's basic education" (p. 1).

In a similar vein, Walker (1985) suggested that a good liberal education for life in a technological society will contain more than a smattering of study in science, mathematics and technology. He elaborated by writing, "The responsibilities of managing our environment are fully as high a calling as those of citizenship traditionally defined. Buildings, bridges, highways and machines are cultural artifacts as characteristically human and worthy of study in their own way as poems, novels, plays and paintings" (p. 97).

Waetjen (1985) presented a parallel view when he wrote, "A central role of an educational institution is to offer a curriculum that gives its students a basic understanding of the society in which they live. Proceeding from that premise, it is logical that in a democratic, technological society, the curriculum would strongly reflect those characteristics" (p. 9).

These and other writings suggest that the educational experience of youth should be enlarged to offer programs that promote general understandings of technology (technological literacy) and that these programs should be viewed as being as important as mathematics, science, social studies, language arts, etc. A major problem faces any person accepting the challenge to develop these educational programs: namely; "How should the curriculum be organized to provide articulated learning." Some states have traveled a provincial, narrow path developing their unique answer to this problem. This path has a number of hazards including (1) a diminished ability to exchange materials with other states, (2) a failure in sending commercial publishers a clear signal for developing text materials for the entire range of technology courses needed, and (3) confusion for students moving in and out of the state.

A better course of action seems to be developing technology education experiences using broader-based philosophies and documents. Boyer (1985) suggested an appropriate avenue when he wrote "your profession must take that remarkable document, the Jackson's Mill statement, and bring it into fashion to the school and the classroom" (p. 6). This paper will address this challenge which has been enlarged to incorporate Jackson's Mill companion document Industry and Technology Education: A Guide for Curriculum Designers, Implementors, and Teachers.

The Jackson's Mill Theory

The Jackson's Mill Industrial Arts Curriculum Symposium was a group of 21 individuals who met over an 18-month span to live the "challenge of inquiry, assimilation, compromise and consensus" (Snyder & Hales, 1981, p. ii). The result was a philosophical position that the several "camps" in the profession could view as a legitimate compromise and, hopefully, use so that the various technology education curriculum efforts would have a common thrust. The key points in this philosophy were:

1) Technology education is a study of technology, industry, and their impacts.

The project document (Snyder & Hales, 1981) states "industrial arts <technology education> is a comprehensive education program concerned with *technology*, its evolution, utilization, and significance; with *industry*, its organization, personnel, systems, techniques, resources, and products; and their social/cultural impacts" (pp. 1-2). This definition was reaffirmed in the Standards for Technology Education Programs (1985, p. 7). Accepting this statement, curriculum planners must develop programs which help students understand creating and using tools to extend the human potential (technology), AND the societal institution developed to convert resources into products and services (industry) AND the impacts these have on individuals and society.

2) The study of technology and industry is best organized around the human technical activities.

The project report (Snyder & Hales, 1981) suggests that the "subsystems of the human technical endeavors are communication, construction, manufacturing, and transportation. Each of the subsystems represent a discrete human endeavor which can be studies in isolation. For example, throughout history people have *manufactured* goods, *constructed* structures, *communicated* ideas, and *transported* goods and people" (p. 23). These four curriculum organizers were defined as follows:

> Communication: a technical adaptive system *designed by people* to efficiently utilize resources to transfer information to extend human potential (p. 26).
>
> Construction: a technical adaptive system *designed by people* to efficiently utilize resources to build structures and constructed works on a site (p. 30).
>
> Manufacturing: a technical adaptive system *designed by people* to efficiently utilize resources to extract and convert raw/recycled materials into industrial standard stock and then into industrial and consumer goods (p. 33).
>
> Transportation: a technical adaptive system *designed by people* to efficiently utilize resources to obtain time and place utility and to attain and maintaindirect physical contact and exchange among individuals and societal units through the movement of materials/goods and people (p. 36).

These definitions appear in slightly edited forms in the Standards for Technology Education Programs (1985, p. 7). Additionally, the Standards suggest that the philosophy of an exemplary program "focuses on the broad systems of communication, construction, manufacturing, and transportation. . .(p. 12) and that the course content be "offered in the broad systems of communication, construction, manufacturing, and transportation (p. 17).

3) Each of the human technical endeavors is a system which has inputs, processes, outputs, feedback, and goals/restraints.

The Jackson's Mill (Snyder & Hales, 1981) document indicates that viewing the four human technical endeavors as systems "suggest there is some regularity to human adaptive behavior and that the elements in the system relate in orderly, predictable ways" (p. 10). It further states that "the inputs to the system provide all the needed resources to accomplish the goals of the system" (p. 11). These inputs are people, knowledge, material, energy, capital, and finance. The systems processes, according to the document, are "a scheme of actions or practices" and are "the technical means of the system" (p. 13) or the technology employed.

4) Each human technical system often are developed into managed productive systems.

The document (Snyder & Hales, 1981) suggests that all four subsystems of the human technical endeavor use "*productive processes* (those activities designed by people which utilize selected inputs to reach desired outputs), and *managerial processes* (those activities designed by people to insure that productive processes are performed efficiently and appropriately) which result in a "managed productive systems (a system developed by people in which each step in the transformation of inputs into outputs is efficiently planned, organized, directed, and controlled with respect to company goals and in concert with society objectives)" (p. 25).

5) Human technical endeavors are dynamic activities which have a history, present practices, and a future.

These philosophical statements were summarized in the Jackson's Mill report (Snyder & Hales, 1981) with the diagram found in Figure 1.

Industry and Technology Education Report

Following the Jackson's Mill project a second project, the Industry and Technology Education Project (1984), was conducted to move the Jackson's Mill Curriculum Theory into model curriculum structures for small-, medium-, and large-sized schools. This project suggested that the "mission of educators in our profession is to increase each person's ability to comprehend and apply the concepts of

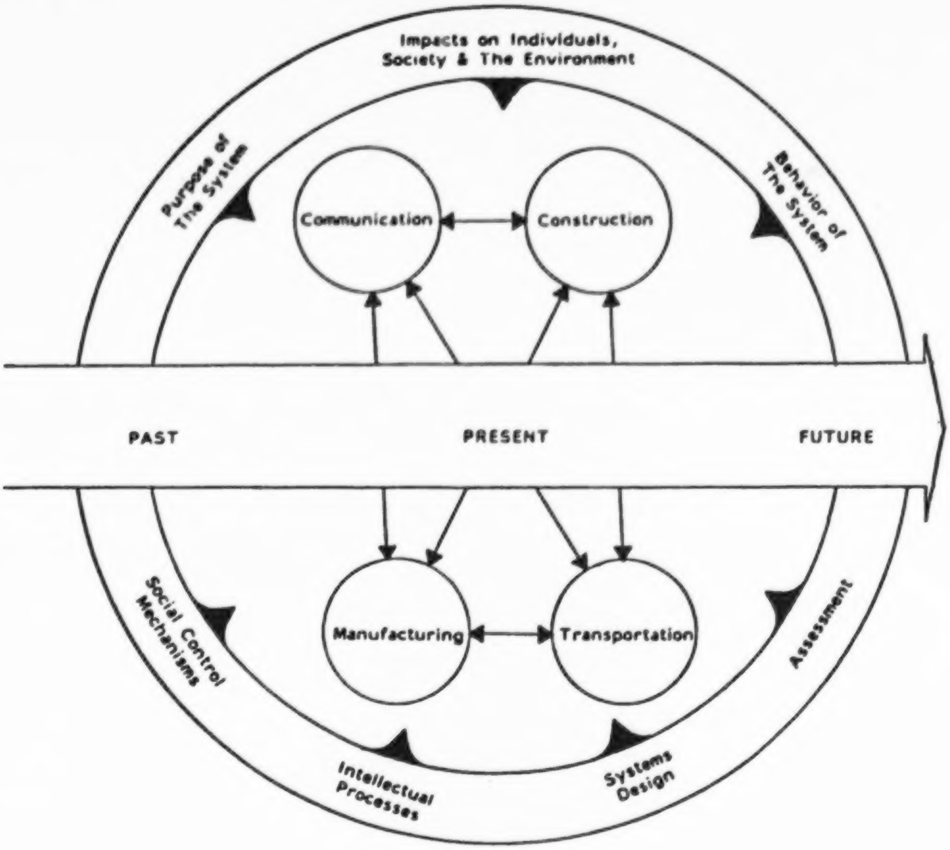

Impacts on Individuals, Society & The Environment
Purpose of The System
Behavior of The System
Communication
Construction
PAST
PRESENT
FUTURE
Manufacturing
Transportation
Social Control Mechanisms
Assessment
Intellectual Processes
Systems Design

Figure 1. The Global Context of Human Technical Adaptive System. (Hales and Snyder, 1983, p.25)

industrial and technological systems" (p.9). There report further suggests that "the study of industry and technology should result in people who (1) adjust to a changing environment, (2) deal with the forces that influence the future, and (3) eagerly participate in controlling their own destiny" (p. 9).

The Industry and Technology Education Project used the Jackson's Mill philosphy to develop program structures based on ten fundamental assumptions, which were:

1. All students need a basic framework of knowledge and experience about industry, technology and their societal context.

2. The foundation must include broad introductory experiences which present the interface between research and development, industrial/technological systems, services, use, and personal-corporate management interaction.

3. The program must include specific experiences in each of the four industrial/ technological systems--communication, construction, manufacturing, and transportation.

4. The experiences in the industrial/ technological systems should include both the productive and the management activities of the system.

5. The industrial/technological systems are best understood if examples are provided of the design of the product or system

and the productive activity within the system.

6. The enrollment of the industrial arts <technology education> program will determine the number and variety of courses that can be offered.

7. Synthesis courses in research and development and in enterprise should be included in the program of any school.

8. Prerequisites <for the various courses> should be minimized to encourage flexibility in student enrollment.

9. All courses should use practical laboratory activities to enhance fundamental conceptual development.

10. Experiences about the industrial/technological systems should be integrated into the elementary school curriculum (Wright & Sterry, 1984, pp. 11-12).

Figure 2 presents the medium-sized program model. A brief outline was developed for each course in each of the three program models. These outlines presented a course description and objectives, content listings, representative activities, and suggested time allotments. Additionally the project report contained content taxonomies for each of the four industrial/technological systems.

Using the Reports to Develop Curriculum

The Jackson's Mill and the Industry and Technology Education Reports provide the curriculum planner with the philosophical basis and content structure guidelines needed to enter the curriculum development process. The first major step, as one enters this process, is to unify support for the undertaking. At a local level central office and building administrators along with the industrial arts (technology education) faculty must see the curriculum change effort as necessary and become a TEAM. At the state level the TEAM must include the state department of education, teacher education institutions, and the state industrial arts (technology education) professional association. Failure to establish the TEAM concept early on will create an environment for failure, or at best, limited success in developing and implementing the curriculum.

Once the curriculum development team is established, a goal-oriented leader who fully understands the Jackson's Mill and Industry and Technology Education Documents and the curriculum

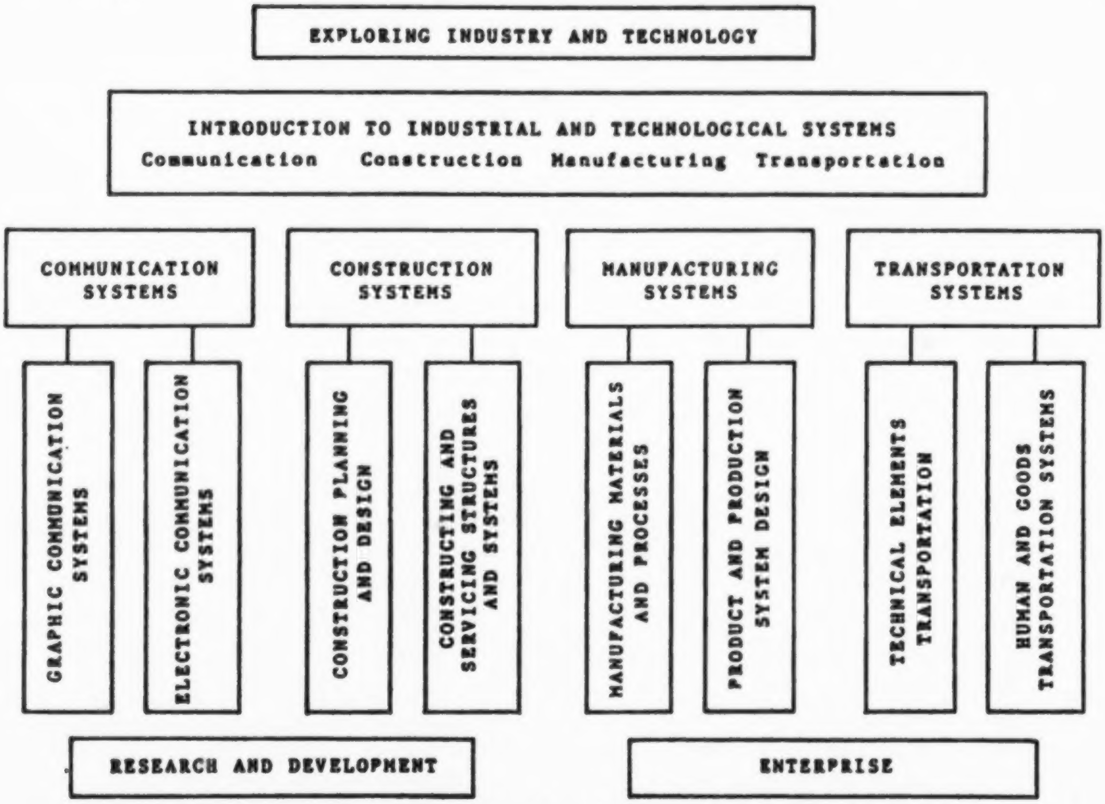

EXPLORING INDUSTRY AND TECHNOLOGY
INTRODUCTION TO INDUSTRIAL AND TECHNOLOGICAL SYSTEMS
Communication
Construction
Manufacturing
Transportation
COMMUNICATION SYSTEMS
CONSTRUCTION SYSTEMS
MANUFACTURING SYSTEMS
TRANSPORTATION SYSTEMS
GRAPHIC COMMUNICATION SYSTEMS
ELECTRONIC COMMUNICATION SYSTEMS
CONSTRUCTION PLANNING AND DESIGN
CONSTRUCTING AND SERVICING STRUCTURES AND SYSTEMS
MANUFACTURING MATERIALS AND PROCESSES
PRODUCT AND PRODUCTION SYSTEM DESIGN
TECHNICAL ELEMENTS TRANSPORTATION
HUMAN AND GOODS TRANSPORTATION SYSTEMS
RESEARCH AND DEVELOPMENT
ENTERPRISE

Figure 2. Medium School Model (Wright & Sterry, 1984, p.16)

development process must be selected. Many curriculum developments have failed due to the lack of clarity of the mission and/or effective leadership. In a recent videotape, Peters (1985) suggested that anything of value that is accomplished is the result of a turned on leader or group - monomanics with a mission.

The curriculum development team, with its effective leader, must then develop an action plan. This plan should have at least five basic steps:

1. Philosophy--The development or acceptance of a philosophy for the curriculum which answers such questions as:
   - (a) What is technology, industry, technology literacy, and technology education?
   - (b) Why should students study technology education?
   - (c) What are the content organizers for a technology education program?
   - (d) What are the goals of technology education?
   - (e) To what extent are laboratory activities important?
   - (f) Does skill development have a place in technology education?
   - (g) What is the relationship of technology education to general education? to vocational education?
   - (h) What student population should be served by technology education?
   - (i) What content is appropriate for technology education?

2. Curriculum Development--Implementing the philosophy into a teachable curriculum. This phase involves a number of tasks including:
   - (a) Selecting program structures with course titles
   - (b) Preparing course descriptions.
   - (c) Selecting major modules (units) for each course.
   - (d) Determining the format for the course guides.
   - (e) Selecting authors or teams of authors to prepare each course.
   - (f) Editing course guides.

3. Pilot Implementation--Testing the curriculum in selected schools. This phase includes the following tasks:
   - (a) Soliciting schools to test the total program (not selected courses).
   - (b) Selecting a limited number of schools (3-6) from the applicants to test the curriculum.
   - (c) Provide administrator, guidance personnel, and teacher inservice.
   - (d) Provide field service and monitor progress during the pilot test.

4. Curriculum Revision--Revise courses based on pilot school results. Use many of the pilot school teacher in the rewrite process.

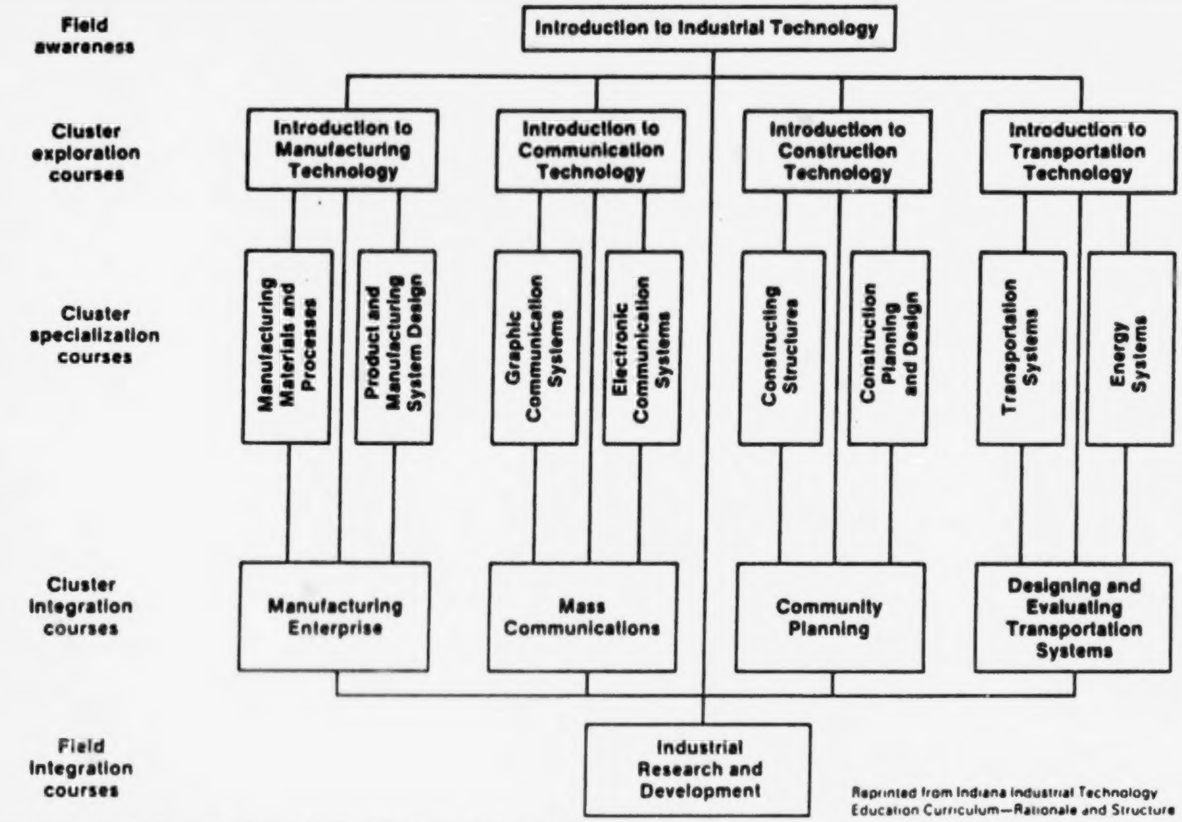
5. State-wide and District-wide Implementation--Introducing the new curriculum to an ever increasing number of schools through a controlled growth plan.

It is important to bring schools on-line with the new curriculum only as fast as inservice and field service activities can be provided.

This plan was used to develop a new curriculum which emphasizes technology literacy for the State of Indiana. The program, as shown in Figure 3, has been pilot tested and will enter state-wide implementation in the Fall of 1988.

The ability of the Indiana Industrial Technology Education Curriculum Committee to move for committee appointment through pilot testing in less than three years is due to at least four factors:

1. Strong cooperation between the Indiana Department of Education, the Indiana Industrial Technology Education Association, and the three Indiana industrial arts teacher education institutions (Ball State, Indiana State, and Purdue Universities).
2. A dedicated curriculum committee with equally dedicated course writing teams.
3. Support emanating from the Governor's office who wrote "It was with a great deal of pleasure that I learned of the efforts of the Indiana Industrial Technology Education Curriculum Committee to develop new curriculum which would be more oriented to the technological future which our school students of today will be facing when they graduate. . .Pursuit of industrial technology


Field awareness
Introduction to Industrial Technology
Cluster exploration courses
Introduction to Manufacturing Technology
Introduction to Communication Technology
Introduction to Construction Technology
Introduction to Transportation Technology
Cluster specialization courses
Manufacturing Materials and Processes
Product and Manufacturing System Design
Graphic Communication Systems
Electronic Communication Systems
Constructing Structures
Construction Planning and Design
Transportation Systems
Energy Systems
Cluster integration courses
Manufacturing Enterprise
Mass Communications
Community Planning
Designing and Evaluating Transportation Systems
Field integration courses
Industrial Research and Development

Reprinted from Indiana Industrial Technology Education Curriculum—Rationale and Structure

Figure 3. Indiana Industrial Technology Education Curriculum Model. (Wright, 1986, p.35)

education along these functional lines <communication, construction, manufacturing, and transportation> will provide a much more useful set of courses than current industrial arts preparation which student receive today" (Orr, 1984).

4. Six school districts and their teachers who were willing to take a risk and accept the challenge of implementing an untested curriculum so that other schools could have a field-tested product.

Developing technology education programs which are viable is made much easier when the change agents decide that much of the essential groundwork is there. The goal of developing a quality technology education program is attainable is a relatively short period of time when they rise above provincial thoughts of developing a unique local or state curriculum and build upon the work of a large number of professionals who participated in both the Jackson's Mill and Industry and Technology Education Projects.

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The Future of Work in America: Workers, the Workplace, and Technological Literacy

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Introduction

Work in the future will depend as much on the characteristics of tomorrow's workers as on the nature of the changing economy. We can be fairly certain about the demographic composition of our country in the next 50 years. We are less certain, however, about the effects of technological and economic changes on the future of work and working. One thing that is certain is that technology is here to stay. It is critical that we prepare a citizenry that is technologically literate if our nation's productivity and economic viability are to remain competitive.

This paper explores the future of work in America focusing on the effects of technology and on the preparation of workers for the technological age of the future. Before outlining the content of the paper, it is necessary to clarify what technology means:

> Technology is the physical devices and apparatus (tools, instruments, machines, appliances) used to perform tasks. It is also the technical activities (skills, methods, routines, procedures, and social organizations) that people engage in to perform the tasks. Technology then, includes
>
> *both* the activities of people and the way their activities are combined with materials and physical devices in organizations and social systems.

Technological literacy is the possession of the skills, knowledge, abilities, and attitudes necessary to effectively use technology as a tool for occupational, educational, or personal use.

The paper begins by tracing the structural changes facing the economy throughout the remainder of this century and well into the next. This discussion sets the context for the remainder of the paper. The second section explores the effects of technology on the nature and availability of work. This is followed by an examination of the preparation required for work in the technological age of the future. The final section offers some conclusions about and challenges for meeting the changing needs of a technologically changing workplace.

Structural Changes in the Economy

Education and workplace policies and practices are developed in response to a complex set of factors. Major demographic, economic, and technological shifts* are predicted for the next quarter center. These have consequences for the workplace and for the preparation of the citizenry that can meet the challenges of the future. (* Because the focus of this paper is on technology, the technological shifts are discussed in Section III.)

Demographic Shifts

The changes in the composition of the U.S. population and in the composition of its labor force have both direct and indirect consequences for the workplace and for the preparation of people to meet the changing needs of that workplace.

Aging of the Population - Since the baby boom of the 1950's the U.S. population has been aging. The number of young adults (16-24 years old) will decline through 1995, affecting the pool of entry-level workers in the labor force.

The 1980s and 1990s will see the baby-boom generation move into middle age, increasing the number of workers thirty to forty-nine years old by 79 percent. By the year 2000, the median age of the U.S. citizenry will be almost thirty-five. The labor market behaviors and attitudes of this cohort of workers will be affected by "generational crowding" or "mid-career compaction." That is, there will be far fewer of the job and career promotions usually associated with the mid-career stage than there will be middle-aged workers. Those who are technologically literate will be at a distinct advantage in competing for these promotions. One consequence of this phenomenon is that many in his cohort will need to make major career and life shifts, looking to other word and nonwork opportunities for their financial, social, and personal rewards. The last baby boomer is 27 and long out of school. Most of this cohort are not technologically literate. They will need lifelong technological literacy training offered through the workplace or through the more traditional providers of education and training.

Medical and nutritional advances will continue to increase life expectancies. While many older workers will retire early, others will remain in or re-enter the labor force, for financial, social, and psychological reasons. New work patterns are expected that will enable these older workers to work part-time (daily, weekly, monthly, or yearly) while pursuing other activities traditionally associated with retirement. These older adults adults also will need to be technologically literate whether they continue to work or not. The services and resources these older persons will need will, to an increasing extent, require them to be technologically literate. They, like their younger counterparts, will need lifelong technological literacy training.

More Women and Minorities in the Labor Force - The numbers and proportion of women in the paid labor force have been steadily growing. It is estimated that women will comprise 65 percent of all new hires during the next ten years and over half of the labor force before the end of the century. At the same time, the population of Blacks and Hispanics in the U.S. work force will steadily increase. By the year 2000, these two groups will constitute almost one-quarter of the work force. Increased immigration (legal and illegal) is expected as a result of shortages of entry-level workers. These groups have traditionally been the last to adapt to new technologies. While women have clearly incorporated new office technologies they generally have not expanded into other areas of technology. Minorities, with their lower levels of education, lower basic skills, and language problems (Hispanics and immigrants), will continue to suffer from technological illiteracy. It is critical, however, that these groups be prepared for the technological age of the future.

Economic Shifts

Major economic shifts and corresponding changes in the employment sector have occurred over the past two decades, and further shifts are expected through the first quarter of the next century. Some of these shifts have been or will be dramatic, while others will be more gradual. What we produce, how we produce, the way we work, and the distribution of jobs are changing and will continue to change. While the speed of these changes has clear implications, it is the changes themselves that will have the major impact on the future.

Decline of the Industrial Sector - In 1984, 30 percent of the work force was employed in the industrial sector. However, this sector has been declining since the early 1950s, and the decline is expected to continue through the next decade, due, in large part, to increased automation and robotization, improved operational procedures, and competition from developing countries with low labor costs. This sector is expected to employ only 11 to 12 percent of the work force by the mid 1990s. The automobile, steel, clothing, and support industries have been affected by the growing trend of importing, which has led to large numbers of displaced or dislocated industrial workers.

Growth of the Service Sector - The service sector is, by far, the dominant sector of employment with about two-thirds of the work force employed in service jobs in 1984. Over 80 percent of the employment growth projected through 1995 is expected to occur in the service sector. The growth of this sector is due to a number of factors. First, the growing proportion of women in the paid work force is increasing the number of dual-income households (75 percent by 1995). These households are "short" on time but "long" on money, and consequently they "buy" more time by purchasing more services, such as meals, home repair, dependent care, and education. In addition, there is an increase in the number of single-parent households, which may not be "long" on money but will need to purchase many services, nonetheless.

A second factor that will affect the growth of this sector will be the millions of workers displaced by automation, technological advances, and foreign competition. Since many service jobs involve relatively unsophisticated, commonplace skills and knowledge, the service sector has always been the natural employer of last resort. The ready supply of displaced workers with limited employable skills will lead to low wages in parts of the service sector and thus will promote the general growth of service-related business. Millions of people use low-level service employment as a transitional phase in their careers, while they acquire some form of retraining to quality for work in higher-paying jobs in the service and other sectors of the economy.

Continued Growth in Self-Employment - Self-employment, which reached a low of seven percent in 1970, has been on the rise since then and is expected to continue to grow. The growth of the service sector and of the information industry within all of the sectors, will reinforce this rise by encouraging independent information and service entrepreneurs. It is projected that self-employment will double by the year 2000 from its low point of 1970. As mid-level, mid-career workers are laid off or not promoted, they will be "forced" to become self-employed in new venture enterprises. Others will see the opportunities for self-realization, independence, and personal advancement in starting their own businesses. The computer software and support industries provide clear examples of this growing phenomenon. In many cases these new entrepreneurs will require technological skills if they hope for their new ventures to be successful.

Growth of International Trade and Third-World Development - Developed countries are rapidly using up their reserves of natural resources while continuing to upgrade the quality of human resources. This will cause increased dependence on developing nations for raw materials and "cheap" labor for mass-produced goods. It is projected that, by the year 2000, one-third of the world's goods and services will be consumed or used outside of the country of origin.

The structural changes that are anticipated for the next twenty-five years are sure to affect the work force, the workplace, the lives of workers, and society in general. The combined effects of the ongoing economic transition, the changing demography of the population and the work force, and the nation's assimilation of new applied technologies assure a steadily increasing demand for training, education, and human resource development.

Technological Effects on Work

From microcomputers to robots, word processors, and genetic engineering, we have witnessed rapid advances in technology in the past two to three decades. These new applied technologies have affected every sector in the labor force and in the general society. Agricultural advances have allowed fewer and fewer farmers to produce more and more. The microcomputer and word processor have transformed the office from one that is largely labor intensive to one that relies heavily on electronic storage and transmission of information, creating the "paperless office." Automation has transformed the assembly lines and factory floors in many industries by using robots to perform the tasks of large numbers of workers. Computer-aided design (CAD) and computer-aided manufacturing (CAM) have been used in a wide array of industries to design and produce new products and systems. Communication has also been affected by new technologies. Teleconferencing (video and audio), satellite systems, videotext, and car phones are just a few of the new communications technologies that have emerged in the past few years. The advances in biological and health sciences, as a result of technological change, are no less staggering.

The high-technology revolution is all around us--in the factory, at the office, in our communication, transportation, and health care systems, and in our homes. The growth of these technologies will continue, but the implications for employment, social relations, and personal development are yet to be fully recognized. In this section I explore some of these implications. I begin with a general discussion and then explore how technology effects the nature and availability of work.

There are many predictions about the ways in which technology will impact work and the workplace. It has been suggested that technology:

- Decreases the skills required to perform jobs.
- Increases the skill requirements of jobs.
- Dramatically increases the mismatches between the skills that jobs require and those available in the workplace.
- Requires that workers be "technologically literate."
- Eliminates many jobs.
- Creates many jobs.

I believe that all of these predictions are true but, in and of themselves, they are too simple. Technological change does not occur in a vacuum. Economic and demographic factors are powerful influences on the adaptation of new technologies in the workplace. Productivity, competitiveness, and profits often dictate when, how, and which technologies will be implemented. Also, technology alone does not determine the availability or nature of jobs.

Technology does not, by, itself, decrease, or increase skills; cause mismatches; or eliminate or create jobs. While technology may set limits or open possibilities, it is the managers and decision makers that ultimately are responsible for determining the options for workers. In other words, new technologies sometimes compel, but more often permit, industries and organizations to reorganize and restructure jobs. And, the impact of technology on workers is primarily determined by management decisions and worker/management relations.

Technology and the Nature of Work

Although technology alone does not determine the nature of work, it is a strong factor in determining work options. Robotization, CAD/CAM systems, and other new manufacturing and industrial technologies are projected to eliminate five to seven million jobs (mostly blue collar) before the turn of the century. Information and communication technologies, on the other hand, are expected to eliminate seven to 12 million white-collar positions. The total loss of jobs is projected to be between 15 and 20 million by the year 2000. At the same time, the production of these new technologies will create two to three million new jobs, while positions related to the maintenance and repair of these new technologies will generate an additional four to five million high-technology service positions. In addition, these new technologies will affect the production of finished information products (books, magazines, disks, cassettes, and video media) in their "publishing" industry. Between 1.5 and 2.5 million jobs are expected to be generated in this area. The net result is a loss of between five and 13 million jobs due to the new technologies.

New technologies can also displace work tasks. Robots that weld car pieces together or new technological processes eliminate tasks performed by workers. Work also can be restructured to use technology, resulting in fewer people performing the same amount of work. The word processor and computerized information system are examples of technologies that reduce the number of workers required to perform specific tasks.

At the same time, new technologies can create work tasks. Medical technicians, for example, will need to learn new skills to perform the new tasks associated with new technological equipment. Auto workers will need to learn programming, machine monitoring, and maintenance to perform new tasks associated with the introduction of robots and automated processes.

New technologies, have other potential effects on the nature and organization of work, including: broader definition of production jobs; the tendency for companies to provide more training; allocation to groups of workers some of the responsibilities vested in foreman and first-line supervisors; motivational and attitudinal factors may weigh more heavily in selection criteria than credentials or past experience; production workers may have a greater say in decisions about new equipment and procedures; product centered work organization will replace compartmentalization; scheduling will be more flexible; the use of temporary workers will increase; part-time work will increase; and multiple job holding will increase.* (* Office of Technology Assessment, Congress of the United States. *Technology and Structural Unemployment: Re-employing Displaced Adults.* Washington, D. C.: U.S. Government Printing Office, 1986.)

Technology and the Availability of Work

The availability of work is influenced by a combination of factors including technology, international trade, domestic competition, and consumer preferences. It is clear, however, that new technologies are transforming many kinds of work and influence the availability of different types of work. The Bureau of Labor Statistics, in its projection of the fastest growing occupations, suggests the potential impact of new technologies. As Table 1 shows, of the ten fastest growing occupations seven are directly related to new technologies while the remaining three are impacted indirectly by new technologies.

Table 1

Change in Employment Occupation 1984 - 1995	**Percent**
Paralegal personnel	97.5
Computer programmers	71.7
Computer systems analysis, electronic data processing (EDP)	68.7
Medical assistants	62.0
Data processing equipment repairers	56.2
Electrical and electronics engineers	52.8
Electrical and electronics technicians and technologists	50.7
Computer operators, except peripheral equipment	46.1
Peripheral EDP equipment operators	45.0
Travel agents	43.9

(Source: Silvesti, G., & Lukasiewics, J. (1984, November). Occupation of employment projections: The 1984-1995 outlook. Monthly Labor Review, 108(11), 51-52.)

In addition to the growth in a number of specific occupations there are a number of general trends that have emerged. First, in manufacturing, job opportunities will probably increase for technicians, mechanics, repairers, and installers, as well as for engineers and computer scientists. At the same time opportunities for all production workers will fall. This includes operatives, laborers, machinists, and press operators. Lower and middle management job opportunities may also decline. Second, in offices growth opportunities will more than likely slow down and by the 1990's may show a decline. There too, opportunities for lower and middle managers will fall. Third, new technologies are greatly reducing the number of opportunities in agriculture. Finally, in the service sector, particularly health, and communication related, new technologies are creating new tasks and new occupations.

New technology has an indirect effect on the availability of occupations not directly dependent on the technologies themselves. For example, the increase in free time will result in changes in entertainment ocupations. Those involved in literature, music, the arts, and athletics will be busier than even since their audience will grow steadily.

Service occupations also are projected to increase in the next decade. While not directly due to new technologies, these increses will greatly impact the nature of our society. The Bureau of Labor Statistics, has projected the occupation with the largest job growth. Table 2 presents those occupations with the largest job growth. (See Table 2)

Table 2

Occupation 1984-1995	%of Total Job Growth
Cashiers	3.6
Registered nurses	2.8
Janitors and cleaners	2.8
Truck drivers	2.7
Waiters and waitresses	2.7
Wholesale trade saleworkers	2.3
Nursing aides, orderlies, and attendants	2.2
Salespersons, retail	2.2
Accountants and auditors	1.9
Teachers, kindergarten and elementary	1.9
Secretaries	1.7
Computer programmers	1.5
General office clerks	1.4
Food preparation workers excluding fast food	1.4
Food preparation and service workers, fast food	1.4
Computer systems analysts, electronic data processing	1.3
Electrical and electronics engineers	1.3
Electrical and electronics technicians and technologists	1.3
Guards	1.2
Automotive and motorcycle mechanics	1.2

(Source: Silvestri, G., & Lukasiewics, J. (1984, November). Occupation of employment projections: The 1984-1995 outlook. Monthly Labor Review, 108(11), 51-52.)

At first glance these projections may make us rest easy. While many workers will be displaced by technology or will not possess the skills needed for new technological occupations, htere will be available jobs for them. The problem, however, is twofold. First many workers who are displaced cannot "afford" to take these available jobs. That is, the available jobs tend to be lower paying (substantially) than the jobs workers wer forced to leave. Second the workers who do not possess the necessary skills for the technological jobs will tend to be less educated, minority, limited English proficient, and/or older adults. The result may be a class, no a caste, society like none we have seen since the slaves were freed. Unless we can change this trend the very foundation of our nation's fabric will be greatly deteriorated.

That technology is, and will continue to be, a major influence on the nature and availability of work cannot be denied. Changes in technology disrupt existing industries, making some jobs obsolete and reducing opportunities in other occupations. The nature of work also is altered by technological change. While technology eliminates the demand for some skills and occupations it creates new products, new markets, and new jobs. Technological changes also effect non-technologically-based occupations. One potential result of technological change will be a greater division of labor between those citizens who are technologically literate and those who are not. The chasm, in terms of opportunities, income, and standard of living is potentially very wide and threatening to the future of work, workers and the society in general.

Preparation for Work in a Technological Age

Preparation for work in a technologically changing workplace, to a large extent, depends on the skills, knowledge, and abilities needed by different groups of workers. For this discussion I focus on the preparation of three groups of workers: entry level workers, mid-career and older workers; and managers. It should be pointed out at the outset that my discussion is general and does not focus on specific sectors, occupations, or types of work.

At its most basic level, preparation for work in the technological age means preparing people to be flexible and adaptable to change. There are other skills that are also needed. One set of skills is directly related to the technology itself. For example office workers need to learn word processing skills, auto workers need to learn to operate robots, and medical technicians need to learn about automatic instruments.

Other skills are less technology specific. Workers will find that manual and routine mental skills will be in less demand than the capacity for judgment and evaluation, an understanding of technological equipment, the ability to spot problems, and an understanding of how one's own work fits into the larger picture. Social skills such as teamwork and communication will be increasingly valuable for workers. New organizational approaches that encourage workers to participate in solving problems and making decisions will require new skills for managers.

For workers the skills that could be in demand will require a good basic education. If workers can not read they can not be technologically literate. If they cannot do math, think, analyze, and learn they cannot be technologically literate. And, if they can not work with others, communicate, and make decisions they cannot be technologically literate.

A new conceptualization of technological literacy will be required for managers and corporate decision makers. It will require them not only to understand machine or apparatus technologies but "social technologies" which will be necessary to organize and coordinate human resources, as well.

How do we prepare people for the new and difficult roles and responsibilities they will have in a technologically changing workplace? The process will be different for different groups of workers.

Preparing Entry Level Workers

High school graduates looking for their first fulltime jobs need basic skills--communication, mathematics, problem solving, working on a team, decision making, "learning to learn"--for successful entry into a technologically changing workplace. Most of their technological training will take place in the workplace after they have jobs. They should, however, have some familiarity with basic technological equipment, especially computers. In addition, these entry level workers should understand how technology affects work, working, the workplace, and society in general.

The college graduate entering her or his first fulltime job also will need to be prepared for a technologically changing workplace. While many of these will enter directly into positions requiring specific technological skills others will be managers and decision makers. As such they will need to be "literate" in both the machine and human sides of technology.

The preparation of both groups of entry level workers rests with our elementary, secondary, and postsecondary education systems. Early emphasis at the elementary and secondary school levels must be placed on the basic skills outlined above. The lack of these skills will greatly limit the options for entry level workers. Access to math, science, and technology skills should also be increased. These skills are critical for further education and training in technological occupations. Also, education at this level must stress the human side of technology and an understanding of how technology impacts work and society. Our elementary and secondary education system must provide students with the skills and knowledge they will need to cope with a changing environment. We must teach our students to be flexible and adaptable and we must do this by connecting the educational system to the real world, in both theory and practice.

At the postsecondary level the focus should be on delivery of technology specific curriculum as well as a solid general education. The technology specific curriculum requires postsecondary education systems to adapt to the changing technology of the workplace and society. In addition, the postsecondary institutions need to be concerned with preparing the future managers and decision-makers of the workplace. This requires preparing students in the human resource side of technology as well as in organizational approaches that effectively integrate people and equipment.

Preparing Mid-Career and Older Workers

New technology will require the (re)training and education of mid-career and older workers. While preparation will necessarily have to focus on basic, social, and specific technology skills, there are a number of barriers faced by adults that need to be addressed before we can even attempt to prepare them for a new technological age. These barriers are categorized as follows:

Structural barriers are those factors which arise out of an individual's position in a family, workplace, a social group at a given time. *Social-psychological barriers* are those factors related to the attitudes, and self-perceptions an individual has or to the influence of significant others on the action of the individual. Structural barriers are policies and practices of organizations that overtly or subtly exclude or discourage adults from participation in education or training activities. Table 3 provides a listing of the specific factors that fall under each category of barriers.

Table 3

Category	**Specific Factors**
Situational Barriers	* Costs
	* Lack of time
	* Age
	* Prior educational attainment
	* Home responsibilities
	* Job responsibilities
	* Occupational status
	* Level of income
Social-Psychological Barriers	* Lack of confidence in ability
	* Feeling too old
	* Low self-concept
	* Tired of school
	* Lack of interest
	* Family or friends don't like the idea
Structural Barriers	* Course scheduling
	* Work schedule
	* Inconvenient location of courses
	* Financial support restrictions
	* Too long to complete program
	* Too much red tape
	* Lack of information on program
	* Lack of information on support assistance
	* Inadequate counseling

With regard to preparation of adults to meet the requirements of new technologies a number of critical elements are required to overcome these barriers including: low costs, employer financed training; support services; short length of training; programs at the workplace; remediation; peer instruction; counseling; clear links to future work; programs offered in the community; experiential learning options; and joint programs of business and education.

Two basic delivery strategies that can incorporate all or most of these critical elements are possible. The first are employer provided education and training programs offered in-house or through contracts with education and training providers. The programs should respond to changes in a company's technology, organization, or products. Currently, the private sector spends $30-$100 billion annually on corporate training programs with a larger and larger share going to remedial math and reading instruction. Further efforts by employers should focus on preparing workers to meet the anticipated changes brought on by new technology.

The second delivery strategy includes the array of offerings provided by education institutions including public school systems, noncollegiate postsecondary schools,two-year colleges, and four-year colleges and universities.

Educational institutions at all levels would do well to rethink their missions in terms of preparing adult workers to meet the needs of a changing workplace. Training and retraining will become ever more important as new skills are needed by workers over their life span. Educators should begin thinking in proactive terms, anticipating changing educational demands, rather than simply reacting to crisis situations related to the immediate needs of the moment.

If demographic and economic conditions do not bring employers to invest more resources in industry-provided training, then, once again, the responsibility will revert to the educational system. As others have suggested, we may be moving toward a "truly continuing educational systems--one that is more flexible and better adapted to shorter term passages."

For the educational system to be responsive to the needs of adult workers, it must look beyond its traditional role of education of youth toward its emerging role in training adults. The educational system must be responsive to the diverse needs of a diverse society, but education and training providers cannot work alone; they must work collaboratively with business, labor, government, and other educational organizations.

Such collaborative efforts are important because technologies have expanded rapidly in many sectors of the economy. This has resulted in a formidable training task. It is critical that this process ensure the equitable availability of training in all aspects of new technologies for all current and future members of the workforce. Training that prepares workers to be flexible, adaptable, and competent in the basic, social, and technical skills that will be needed in the future.

Preparing Managers and Decision Makers

New technologies can only be implemented by human decisions. Human decisions are also central in the distribution of the benefits of change, including the economic growth made possible by greater productivity, and the improved quality of work life in safer and more pleasant surroundings. Some of these implementation decisions impose significant costs on the people least able to bear them, in the form of extended unemployment and reduced earnings prospects. Decisions should take human resource impacts into account to reduce these costs and redistribute them more in accordance with the distribution of the benefits of change, which should also be made more equitable. There also may be a need to better control the pace of technological change in order to minimize the social and personal costs of groups of workers.

These decisions are, to a large degree, made by managers and other corporate decision makers. These individuals need to be prepared for the changes in workers, and the workplace that will result from changes in technology.

The successful integration of technology and human potential is dependent on the adequate preparation of creative and motivated managers. Managers will need new sets of competencies. They will need to become skilled not only in the new technologies and in the new methods of organization and human resource development, but in the sociotechnical systems or "humanware" that integrate the two. Managers will need to look at the whole system--the people, the work, the culture, the technology, the demand, and the market--and be able to link hardware and human resources effectively.

This notion of a "humanware" manager will require the ongoing education and training of managers on human resource strategies and technological advances. Because of the need for training, retraining, communication, and cooperation in the "new" work environment, managers will need to be prepared to lead in each of these areas. This will require time, commitment, and energy. It will also require managers to take on the roles of "coach" and "resource agents" for the teams of workers they supervise. Training programs, whether at the graduate level in formal higher education programs, through executive or management training offered through the workplace, or a combination of the two, should stress the new sets of competencies required by managers of sociotechnical systems. Such programs should be interdisciplinary focusing on the sociology, economics, politics, history, philosophy, and psychology of managing a work environment that is characterized more by change than stability.

Conclusions and Challenges

The principal resource of the U.S. economy is not its great stock of money, plants, equipment, or technology, nor its abundant natural resources and rich farmland. Rather, it is its human resource. A human resource that is knowledgeable, skilled, enthusiastic, and versatile. A human resource, however, that is dependent on education and training throughout their lives, to maintain these characteristics in light of rapid economic and technological changes. Our nation's ability to respond to competitive challenges, to an ever increasing extent, is dependent on the quality and quantity of education and training offered to an engaged in by workers.

The challenge is for employers, workers, unions, government, and educators to work together to respond to the need for a skilled, trained, and trainable workforce. This will require new roles for and relationships among these sectors.

Entry level workers will need to be better prepared to meet the changing work and nonwork worlds they will face. This task will rest heavily on the shoulders of our public school system. Educational resources should be allocated to the teaching of critical basic skills including: reading, writing, math, communication (oral and aural), decision-making, planning, teamwork and thinking. Entry level workers will need to understand that flexibility and adaptability will be critical in the workplace of the near future. Because the vast majority of technology skill training will occur at the workplace, these enetry level workers will need to be prepared for "lifelong technological literacy training."

Many new entrants, however, will require some preparation before they are ready to work. Vocational schools, technical institutions, and community colleges offer programs that prepare and retrain large numbers of workers. The institutions require up-to-date, state-of-the-art equipment *and* faculty. Private sector employers and the government need to help in these areas. Through direct assistance, tax credits, personnel exchange programs, equipment loans, work experience, and other programs education institutions can better prepare new entrants into the technologically changing workplace.

Much of the impact of economic and technological change is felt at the workplace. Adult workers, today and in the future, need lifelong technological literacy training. More effective and timely workplace learning systems would not only allow us to keep better pace with these changes, but would also encourage more career and human resource development for workers.

Current federal tax policy gives employers greater incentives to invest in machines and research than in people. Comparable incentives are needed for each factor of production: capitol, technology, *and* workers. Through a training tax credit, for example, employers would be encouraged to respond to competitive challenges through human resource, as well as machine investment.

A better understanding of training and development in the workplace is also needed. This would help education and training providers outside the workplace to develop practices that compliment learning on the job. It would also help create stronger linkages between learning on and off the job and encourage more cohesive lifelong learning for workers. Lifelong learning provided, in large part, through employer supported programs including: inhouse education and training; contracts with post-secondary institutions and other providers of education and training; tuition assistance programs; and labor-management cooperative programs.

As state earlier, management decisions are critical to the successful implementation of new technologies and to the nature and quality of work. A new type of manager is needed. One which is sensitive to both the equipment *and* human sides of technology. One that is aware of the critical importance of education and training for workers, and one that recognizes that new and different work organizations will be required to respond to the changing technological workplace. The challenge is for the education and training system to prepare these new managers and for businesses and corporations to identify them and allow them to implement changes at the workplace that will be required in the future.

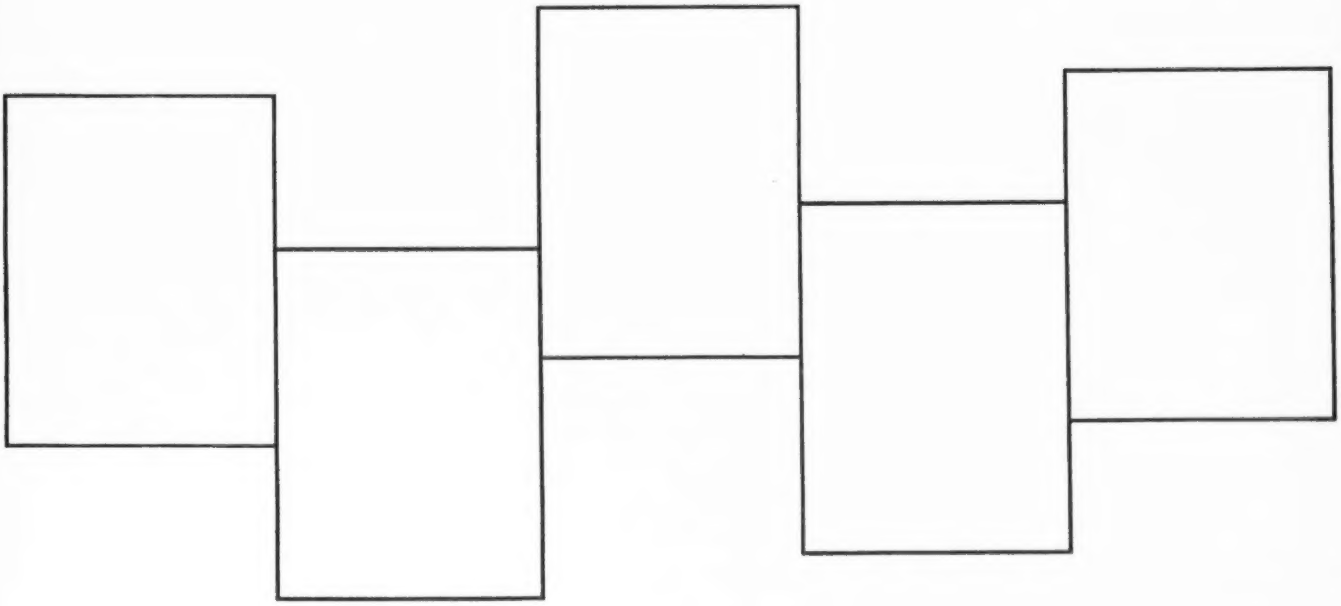
The basic challenge for our education, political, and economic systems is to prepare the human resource to meet the exciting challenges that will emerge as a function of the technological age of the future. A human resource that will be essential to meeting the competitive challenges our nation will be facing. As Isaac Asimov suggests:

> The 21st century, for all its advancement, will be one of the great pioneering periods of human history, as people work under totally new conditions, doing totally new things in totally new ways, taking totally new risks to achieve totally new triumphs.

We need to prepare these pioneers--young and old, male and female, and of all races and ethnic persuasions--to enter, work in, and manage the workplace of the future, and to be trained and retrained throughout their lives.

Without technological literacy that links the hardware and human resources, the future will be bleak. With a technologically literate population the future will be an exciting one full of individual and societal change and triumph. A technologically literate population requires that business, labor, government and education work together in new collaborative ways to the benefit of all.

Technological Literacy Needs in Preservice and Inservice Teacher Education



New Technology, New Lifestyles, and the Implications for Preservice and Inservice Vocational Teacher Education

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In modern society, change occurs so rapidly that it is difficult to imagine what will occur within the next decade. Long term predictions regarding the future are even more difficult to make as the possibilities become unlimited. One item of new technology presents additional items and the influence of technological advancement multiplies.

As technological change continues to accelerate, its application to agriculture, business, industry, health, education and other fields becomes more diverse and more difficult to anticipate. Preparation for employment in current settings is challenging, and the design of vocational education programs requires a great deal of creativity.

As an aspect of becoming technologically literate, vocational teachers need to be aware of recent changes in technology and the influence of such technology. This paper is designed to present an overview of some recent changes in technology, followed by a discussion of changes in personal and professional lifestyles which follow technological change. Changes in personal and professional lifestyles create challenges for vocational educators. These challenges will be overviewed followed by a discussion of the role of preservice and inservice teacher education in assisting vocational teachers in reaching the goal of becoming technologically literate.

New Technology

Society was awakened to the momentum and significance of change by Toffler's (1970) *Future Shock*. Our attention has been confronted by a state of "hyperturbulence" which Selsky and McCann (1984) define as "the condition that results when available resources and institutions prove inadequate to deal with the speed and diversity of change."

In less than forty years, human ingenuity has used technology to carry our society from vacuum tubes to transistors to microchips to superchips to artificial intelligence. Computers, videotext, teletext, teleconferencing, telemarketing, office parks, electronic banking and robots are becoming commonplace tools of business and industry. Many of these tools have enabled the exchange of information to occur at dramatically increased rates.

Such progress is creating both positive and negative results. Members of our society are quickly learning that there are two dimensions to technological progress. Many of the advances in the health sciences, communications and business efficiency have yielded positive results. Yet hackers and the problems of crime, fraud, invasion of privacy and value conflicts continue to create dilemmas.

New Lifestyles

New technology has resulted in new options for personal and professional lifestyles. Homes, work places and schools are changing as a result of new technology. Some indicate that the home is changing from an electronic cottage to an electronic castle.

The electronic cottage concept developed with telecommuting. Through telecommuting, selected workers are able to work from their homes or other locations through the computer. Most of these employees perform work at home, via computer at times of their own choosing.

Telecommuting has both advantages and disadvantages. Some of the advantages include the lack of commuting and parking expenses plus the manageable overhead for companies. The convenience of flexible working hours or "flex-time" is certainly an adantage for selected populations such as parents of young children, older workers and the physically handicapped. The major disadvantage of this work situation is the isolated work environment and the lack of social contacts.

The computer has assisted the creation of the electronic castle. This futuristic home will enable a central computer to control other household computers including robots who will do household chores and basic home maintenance. While driving from the last appointment of the day to home, the homeowner can program the appropriate temperature and humidity, the music desired, the evening meal and a planned program of entertainment in the home media center. Medical alert systems, telephone security systems, smoke and fire detectors will be used and forcefield devices will detect intruders.

Videotext and teletext are entering homes at increased rates. Videotext is a two-way information system that can be summoned with a computer keyboard. The two-way information flow may be made by means of a pushbutton telephone, cable-television system or a cable-television and telephone combination. Teletext is a one-way information service activated by pressing a button or keypad to extract information from the television signal with which it is intermixed. These technologies have strong implications for homes of the future. They enable electronic shopping, banking and correspondence from the homes. Such factors could become important to older populations.

Leisure may become home-based as videogames, cable televisions and videocassette recorders enter the family media center. These concepts also raise some interesting questions. For example, will the electronic home be available to all populations or only the affluent? Will this increase the gap between the rich and poor? Will programs be ncessary to provide access to electronic services for those who have not elected to purchase or who cannot afford to purchase such systems?

Those who elect to leave the home for work activities will find that the world of work is constantly changing. Managerial, administrative and professional roles will not remain constant. In fact, today's worker is not likely to follow a single lifelong career. Work will require retraining and continuing education or professional development. It is difficult if not impossible for today's educational programs to completely prepare individuals who can operate successfully in the age of technology. Business and industry probably do not expect this to occur as they will provide training to help meet these needs.

According to an article in *Time* magazine (February 11, 1985), annual corporate expenditures for education and training have reached $40 billion. This amount is two-thirds of the total annual college and university budgets in the United States. According to Knowles (1977), business and industry spend more money on education for employees and their families and customers than is spent by all higher education, public and private combined. Educators have an opportunity to work with business and industry as some corporations have commissioned technical institutes to provide such training.

Although many jobs will be eliminated with the new technology, others will emerge. With opportunities for training, workers will find new occupations to replace those that become obsolete. Displaced workers will need opportunities to obtain new skills.

As more single parents enter the work force, the need for appropriate child care services has become more and more important. Today, several corporations are providing such centers for preschool children as one aspect of enlightened self-interest. Managers have discovered that workers miss fewer days of work when they have adequate child care.

Teleconferencing is another concept that has been introduced in the workplace. This enables workers to attend meetings in a cost-effective manner. It is not necessary for the worker to be away from the family in order to attend a conference. This method is an excellent manner of educating employees and providing additional professional development.

Computers have also influenced marketing efforts. Telemarketing is now being used to build memberships, raise funds, and obtain new information in addition to making sales.

Today's lifestyle is an enlightened one. As a result of technology, individuals are aware of what is occurring in a global context. News is transmitted at increased rates of speed. In many instances, the public watches the news as it occurs. Cable television provides constant contact with news in the making.

Challenges of New Technology and New Lifestyles

New technology results in new lifestyles and these items create challenges for educators and particularly vocational educators. Some of these challenges include:

1. Assisting students in developing appropriate skills in the areas of reading, writing, listening, speaking, computing basic math and solving problems.
2. Helping students realize the importance of the computer and assisting in the development of computer literacy.

3. Helping learners gain appropriate insight and ethical judgments needed in the age of technology.
4. Assisting learners in the process of identifying bias, propaganda, and other techniques which short-circuit personal knowledge.
5. Accepting and promoting the concept of life-long learning.
6. Learning to work cooperatively with business and industry in order to provide training and development for employees.
7. Assisting in the development of appropriate child care centers for employees.
8. Preparing individuals for the growing service industry where employment opportunities are increasing.
9. Conducting research regarding the impact of technology on workers, the work place, the home, the family, school, and the learner(s).

Such challenges will not be resolved without the assistance of preservice and inservice vocational teacher education which will prepare vocational educators to meet their roles.

Implications for Vocational Teacher Education

Vocational teacher education is challenged to provide teachers who are technologically literate and able to assist in solving the challenges that society will face with new technology and the resulting lifestyles. In order to meet this challenge, vocational educators will need to work with business and industry in order to design effective programs. In addition to having adequate equipment and funds for training, personnel from business and industry will be futuristic thinkers who desire creativity and productivity from workers.

Vocational education must move beyond advisory committees, the cooperative method of instruction and staff industry exchanges to produce more productive partnerships with business and industry. Vocational teacher education is challenged to prepare teachers who are able to work in this capacity. Such teachers should be effective change agents who are able to work with diverse cultures in global markets.

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Technology and Education: The Appropriate Threads for a Complex Tapestry

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Introduction

The issue of technology being taught in our schools brings with it a variety of questions that need our utmost attention as well as our resolve. The tremendous changes in industrial arts/technology education have emerged during the same period of time that teacher education programs have been undergoing comprehensive internal and external scrutiny. This appears to be an appropriate time for rethinking the relationship of several of the many threads that make up the broad picture (tapestry) of education in general and practical arts and vocational education in particular. The selected threads woven into this presentation will involve: (1) the mission of secondary education, (2) the scope of teacher preparation programs for technology teachers, (3) the relationship between technology education and trade and industrial education, and (4) technological literacy.

Mission of Secondary Education

More than thirty reports issued by task forces, commissions, and individuals mandate that urgent attention be given to our schools. Most of these reports emphasize the need to better prepare students for entering college. Yet, a college education is not the choice of the majority. Seventy-five percent of high school youth never graduate from college. Even more drastic, recent data indicate that 3,000 students each day drop out of high school in the United States. Those who plan and conduct secondary education cannot ignore these data.

The Committee for Economic Development (1985) published a document focusing on the investment we place in our children. A push was made for placing academics first on the priority list in education. It would be difficult to find an educator that would oppose this recommendation. However, this does not imply that all educators have to teach the "basics." When a student reaches the secondary level, should not the teacher be able to assume that the student has accomplished grade-level competencies? Those of us in education know that we cannot make this assumption--but why not? Should not students academically below grade-level be the exception? A history of poor academic achievement develops long before a student reaches the secondary level and especially before selecting an occupationally specific program. The remedy must lie in requiring much greater attention to basics while children are in elementary and junior high school. Better and earlier academic instruction for students would produce a larger payoff for instructors of practical arts and vocational education. Student performance in the classroom would improve, communication and computational skills would be enhanced, and problem solving techniques would have a sharper focus. All of these student characteristics are required by virtually all of today's employers for entry level positions. This is not to say that communication and computational skills would be ignored by teachers in vocational education. However, many vocational education and technology education instructors are ill-equipped for the demanding task of remediation. If vocational instructors have to spend considerable time on remediation, less time is available to deliver quality job-specific training in these ever-expanding and more complex technical areas.

A report by the National Academy of Science (1984) on high schools and the changing workplace stated that the largest segment of the American work force consists of high school graduates who have not attended college, and that the nation's economic well-being depends to a very large degree upon their performance. The report concluded that every high school graduate should possess: (1) the ability to learn and to adapt to changes in the workplace, (2) mastery of core competencies, and (3) a positive attitude and sound work habits. The pattern of future job opportunities is very complex. However, it is almost a certainty that today's young people will face, during their 45 to 50 years working careers, cumulative technological and organizational changes every bit as large as those that confronted their parents.

As an important "new basic" in the educational effort, technology education must be perceived and implemented in the context of the modern school setting. Even students can see the importance of dealing with technological issues in their education. Irwin Hoffman (1987), a high school teacher from Denver, asked his high school students, "What should the school in the future offer?" The students developed six areas that all high school students would be involved with before graduation, which include:

1. The Shrinking World
2. Environmental Issues
3. Moral Issues
4. Technological Issues
5. Recreation
6. The Future

Students realize that they need to know how to live in today's society with an understanding of today's technology. Perhaps we can learn from them as we consider the mission of secondary education and the role technology education in this mission. For some educators the resistance to change is strong, but we must continually remind ourselves that students must be prepared to enter a rapidly changing job market--a market built on today's and tomorrow's technology.

Within the field of technology education, there are numerous decisions to be made regarding the specific mission of the field. For example, some believe that distinctions should be made in the middle school and high school setting among the following missions:

1. Exploratory programs to assist in career choice.
2. Programs geared toward specific entry-level positions.
3. Job search and employability skills.
4. Employment counseling
5. Participation in joint venture with employers.

We need to clarify the mission of technology education and the role of trade and industrial education in the total educational program. Understanding and supporting a collective mission will fuel our individual efforts on the local levels.

Other decisions that we face include the specific planning and implementation of programs in terms of a standardized curriculum as opposed to the academic freedom of the instructor. Certain groups at the state level want a great deal of standardization of curriculum which will result in student achievement data. Other groups desire flexibility and freedom. The main problem is to what degree can academic freedom be exercised at a time when the profession is being asked to document what students know and can do as a result of being in a particular program?

Teacher Preparation in Technology Education

Clearly, the strength of our discipline depends on the development and maintenance of an efficient and effective technology education system at the local level. Maintaining a strong, quality-driven technology education system rests with the preparation of competent and caring teachers. After students, teachers are the most important people in the schools.

Teachers are the only producers of learning in the education business. Researchers have identified which teaching methods work well; school administrators have organized facilities and created the proper climate for good teaching; state departments of education have conducted program evaluations; and legislators have tried to provide the financial support for quality education. But in the last analysis, what counts most is the teacher's performance in any given classroom.

We can ask ourselves two questions: (1) what kind of teachers do we need in technology education, and (2) what kind of teacher education programs do we need in technology education? To address the first question, one can turn to Joseph Epstein and his book, *Masters: Portraits of Great Teachers*. Epstein described teaching as a performing art and likened it to opera. He found that in teaching, like singing, there is many a tried, but no true, method or technique for getting the subject across. However, Epstein found that *all* great teachers have some common characteristics, which include:

1. Love of their subject
2. An obvious satisfaction in arousing this love in their students
3. An ability to convince them that what they are being taught is deadly serious.
   (Lewis, 1981)

These qualities describe in part the kind of teachers we need in technology education. Many of us already know outstanding technology teachers who possess these characteristics and have observed the powerful, positive influence they have over their students and the quality of their programs. Of course, the beginning technology education teacher should also have a fair understanding of our present technological society, a broad picture of the industrial and technological trends of our time and their implications for the educational program (Whitesel, 1956).

What kind of teacher education programs do we need in technology education? Do we need to deemphasize skill training and focus on technological concepts? Do we place too much emphasis on traditional skill training, while neglecting more current technologies? How do we divide the time and effort devoted to the general education, major, and professional education components? Many of us are strongly aware of the differing opinions on these questions, but to strengthen our field we need to unify our ideas of how to produce the best possible teacher of technology education. This teacher will have to have a basis understanding of the broad range of today's technologies--something every future teacher must be prepared to do. According to DeVore, Maughan, and Griscon (1979), "The perpetuation of manipulated skill training and teacher education programs to the exclusion of the study of technology, technological systems, and other related disciplines that contribute to the understanding of behavior of sociological, ideological, and ecological systems and their interrelationship, produces an educator incapable of rising to the challenge" (p. 214).

Research has been conducted to investigate areas of professional education preparation that are necessary for technology education teachers. Foster, Kozak, and Price (1985) found that a curriculum for preparing technology education teachers should include elements related to:

1. Discipline in the classroom
2. Planning, organizing and conducting instruction
3. Financial responsibilities
4. Awareness of curriculum changes in the field
5. Middle school and high school experiences
6. Student organizations.

This list is by no means exhaustive, but it gives us a common core from which to build our teacher education program.

The only standardized external evaluation we have of our teacher education programs is the National Teacher Exam (NTE). The technical portion of the teacher preparation curriculum can be evaluated through the results of the NTE specialty examination. The broad spectrum of technologies covered on the specialty exam will give us some indication of our success in preparing future-oriented teachers. However, the true test of our success can only be measured by the secondary student's achievement brought about by the efforts of the technology teacher. At this time we do not have a standardized examination for evaluating achievement at the secondary level.

Excellence in technology education teacher preparation will require honest leaders with much vitality, a commitment to developing evaluation instrumentation centered around critical competencies related to technological literacy, the fine tuning of our teacher preparation programs based upon outcome results, and the support of a strong professional organization.

Technology Education and Trade and Industrial Education

As we look at occupational requirements for the future, it is becoming more evident that specific craft skills will give way to understanding systems and that skills will need to be transferrable so they can be applied in a variety of situations. Vocational education will no longer be a narrow field of study. Rather than an inadequate remedy of quick legislation for a stalled economy, vocational education will prepare students for careers of challenges and changes--not just for a first job. We must carefully define what we mean by the technical basics. We must also describe in detail the roles and relationships between technology education and that of trade and industrial education. There are many differences between the two programs: teachers with degrees versus teachers with work experience; teachers that are familiar with a wide range of technologies versus teachers who are highly specialized within a single occupational area, teachers dealing with exploration versus teachers preparing students for employment--the comparisons can go on and on. Admist the many difference, however, there is one thing they have in common--the lack of trust they feel for each other. The trade and industrial education instructor does not totally trust the technology instructor to teach the technical basics that relate to occupational preparation. The technology teacher does not totally trust the trade and industrial education teacher to prepare students for careers of changes and challenges. The truth is that each knows very little about the other. In this age of keen competition for students, the technology teacher and the trade and industry teacher must educate themselves about the other and join forces to build strength into our programs.

A quality middle grades exploration program can benefit it boh technology education and trade and industrial education by alerting young people to the vast number of technical careers requiring high school or college credentials. In many states the largest technology education enrollment is at the middle school level. We must use this resource wisely.

Technological Literacy

The most difficult, yet one of the most important threads to weave into this tapestry of education is that of technological literacy. Without this thread, the impact of practical arts and vocational education will be less than what it could and should be. However, at this point the process of defining technological literacy and the selecting of components from our discipline which relate to technological literacy is precarious in nature. Funded research of a continuing nature is needed to identify and analyze these components.

The possession of a broad knowledge of technical basics, together with the necessary attitudes and physical abilities to implement this knowledge in a safe, appropriate, efficient and effective manner is part of technological literacy. Being technologically literate also requires that one be able to perform tasks using tools, machines, materials, and processes resulting from technology (Dyrenfurth, 1985). A recent study (Foster, 1986) concluded that a technologically literate person would: (1) be ability to use the design process in the solution of technical problems, (2) be knowledgeable of computer applications, (3) use acquired knowledge to further their educational career, and (4) understanding systems, processes, machines and materials.

In a democracy where it is claimed that all people should have a right to determine their future, a citizenry that is knowledgeable of technology is important. Therefore, as a part of general education all citizens should study fundamental technological systems as routinely as they acquire other skills for literacy (Richter, 1980).

Summary

The mission of secondary education in the United States is under close scrutiny. Teacher education programs have proposed vast changes for the future. The role of technology education and trade and industrial education is being reviewed at the local, state, and national levels. Technological literacy holds much promise.

The job of weaving the tapestry is before us. But before the appropriate threads can be chosen, someone has to have a glimpse of the finished work. Leaders with vision--step forward.

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Computer Literacy: An Essential Element of Technology Literacy

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Introduction

Microelectronics have revolutionized the world of work in industry, agriculture, health, home economics, and business. The microprocessor has not only changed the world of work to include robotics, optical scanners, and word processors, it has changed our everyday lives with devices like programmable appliances, personal computers, and automatic teller machines (ATM). Computers have become an everyday fact of life.

The advent of the inexpensive microcomputer has revolutionized information technology in much the same way as Gutenburg's printing press. The widespread availability of the printed word created a need for people to be literate. Recent innovations in computer technology have necessitated a new kind of literacy. This paper will address the relationship between computer literacy and technological literacy, identify definitions for computer literacy, and identify the computer literacy needs of preservice and inservice practical arts and vocational educators.

Computer Versus Technological Literacy

To help prepare students for a life in a society inundated with computers, most of our schools have established microcomputer laboratories and have implemented computer literacy courses. Unfortunately, computer literacy falls short of a greater and more urgent need, technological literacy. While computer literacy is essential to technological literacy, it does not constitute technological literacy. It is merely a significant part of a greater whole. In the same way electronic switching systems have become an essential part of telecommunications, computer literacy is an essential part of technological literacy. Being computer literate can help one understand how a telephone number is processed. However, it contributes little to understanding the network of transducers, transmitters, receivers, and links that make up a telecommunication system.

Without a basic understanding of the technological systems at work in our society, one has essentially surrendered control to those who do. In order to participate fully in our technological society, one must be more than computer literate. However, the attention already given to computer literacy can help schools meet the technological literacy of their students.

The microcomputer is an indispensible teaching tool when preparing students for life and work in our technological society. It can facilitate learning experience that would otherwise be impossible in a traditional facility. With simulation software, a microcomputer can be transformed into a nuclear power plant, a flight simulator, an automated factory, or an electronic bulletin board. With CAI software, students can explore topics ranging from careers to robotics, from animal husbandry to AC and DC circuits. With applications software, students can experience real world computer application in areas like agribusiness, biofeedback, cardiovascular fitness, word processing, dietary analysis, electronic publishing, computer-aided design/drafting, and computer-aided manufacturing.

In order to address the technological literacy needs of students, it is safe to say, practical arts and vocational educators need to be computer literate. Unfortunately, while a whole generation is growing up with computers as part of their lives, some practical arts and vocational educators report they have never used a microcomputer (Welty, 1987). Both preservice and inservice teachers need to become computer literate, learn how to integrate computer technology into the curriculum, and be able to utilize the microcomputer as a teaching tool.

Defining Computer Literacy

A review of educational computing literature will uncover a variety of definitions for computer literacy. Given the evolutionary nature of computer technology and the growing number of applications for computer technology, it seems unlikely that a single agreed upon definition for computer literacy is forthcoming. To identify what constitutes computer literacy, one must synthesize several definitions.

In a study sponsored by the National Center for Educational Statistics, Lockheed, Hunter, and Anderson (1984) provided the following definition for computer literacy.

> Computer literacy may be defined as whatever a person needs to know and do with computers in order to function competently in our information-based society.
>
> Computer literacy includes three kinds of competence: skills, knowledge, and understanding. It includes:
>
> 1. the ability to use and instruct computers to aid in learning, solving problems, and managing information;
>
> 2. knowledge of functions, applications, capabilities, limitations, and social implications of computers and related technology; and
>
> 3. understanding needed to learn and evaluate new applications and social issues as they arise. (p. 8)

Watt (1980) defined computer literacy as that collection of skills, knowledge, understandings, values, and relationships that allows a person to function comfortably as a productive citizen in a computer-oriented society. He suggests that a computer literate person should be able to: (a) program and control a computer for personal, academic, and professional goals; (b) use a variety of computer-applications software within a personal, academic, and professional context; (c) understand the increasing social, economic and psychological impacts that computers are having on groups and individuals; and (d) make use of ideas from computer programming and computer applications as a part of an individual's strategy for retrieving information, communicating, and problem solving.

For purposes of discussion, Hunter and Aiken (1984) adopted the following definition in a report prepared for the U.S. Department of Education, *Computer Literacy in Vocational Education: Perspectives and Directions.*

> Computer literacy may be defined as the ability to use computers and associated information technologies in ways which enhance one's productivity, creativity, and ability to solve problems and communicate effectively with others. (p. 17)

Kay (1984) emphasizes the affective aspects of computer literacy in the following definition:

> Computer literacy is a contact with the activity of computing deep enough to make the computational equivalent of reading and writing fluent and enjoyable. (p. 59)

Computer Literacy in Teacher Education

With an idea of what constitutes computer literacy, the next step is to identify a set of competencies that characterize a computer literate educator. The author would like to propose the following list of computer competencies for teachers addressing technological literacy.

As a result of their preservice and/or inservice education, vocational and practical arts educators should be able to:

* explain how a computer works and use common computer terminology.
* use software for self-instruction, information collection and retrieval, modeling, simulations, problem-solving, and word processing.
* analyze and describe a simple problem using pseudo code, flow charts, or a high level computer language.
* relate a variety of computer applications in the world of work and in everyday life.
* describe the social and economic issues caused by computer technology.
* evaluate, select, and adapt commercial software for technology education.
* develop and integrate computer-based learning activities into technology education programs.

The importance of programming needs to be kept in perspective. Only a small percentage of those who use computers need to know how to program computers. However, learning how computer programs are structured and encoded is basic to undertstanding how computers process information. In terms of technological literacy, some programming experience can help the computer user think logically, develop problem-solving skills, appreciate software, and discover the real power of computing lies with people.

Some research suggests the greatest challenge for teacher educators is inservice. Vocational educators seem to know very little about microcomputers and their potential as a teaching tool (Yuen, 1984; Foell, 1984). In addition, experienced vocational educators tend to be less receptive to educational computing than inexperienced and preservice teachers (Yuen, 1984; Foell, 1984). Inservice activities should emphasize "hands-on" learning activities using "user-friendly" software and de-emphasize the technical aspects of computers and programming (Foell, 1984; Welty, 1987).

In terms of preservice, Hunter and Aiken (1987) recommend integrating computer-based tools and methods into the curriculum in contrast to addressing computer technology as an isolated subject. In addition, preservice teachers need to learn how to use the computers and software packages commonly found in schools.

Given the financial constraints in education, it is often impossible to replicate the computer technology found in business and industry. Therefore, both preservice and inservice teachers need to learn how to simulate real world technology using education level software and hardware. In addition, they need to learn how to identify and present the concepts being simulated and transfer them to real world applications. For example, industrial educators need to be able to teach the concept of electronic publishing by having students make a poster or newsletter on a microcomputer.

Summary

Computer technology represents one of the most powerful and versatile information processing tools developed by humankind. Vocational and practical arts educators can not ignore a technology as pervasive in our culture as computer technology. If they are going to address the technological literacy needs of their students, they need to contribute to and build on the computer literacy movement in their school. To achieve this goal, preservice and inservice teacher education programs need to produce computer literate educators.

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Computer Anxiety Levels Related to Computer Use and Teacher Inservice Educational Needs

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Introduction

Managing the increased use of microcomputers at all educational levels continues to be one of the greatest challenges facing educators of the 1980s. *U.S. News and World Report* (Malpiedi, Papritan, & Lichtensteiger, 1985) estimated that educators and students in 86% of all U.S. schools now have access to microcomputers. Seventy-five percent of the students and teachers studied by Marshall and Bannon (1985) agreed that people will not be able to escape the influence of computers on their lives.

Simply having microcomputers in the schools serves few purposes unless students and teachers are prepared to use them. Authors (Willis, Johnson, & Dixon, 1983; Zahniser, Long, & Nasman, 1983; Becker, 1984) agree that the uses for computers in education include the following: computer assisted instruction (CAI), computer managed instruction (CMI), computer literacy, and occupational applications - word processing, data base management, and word processing. Vocational educators tend to support the importance of students and teachers learning to use occupational application software and curriculum related software used as computer assisted instruction software. New York vocational educators indicated that occupational application software was used most frequently and while teachers agreed that the ability to use CAI was important, in practice, CAI was seldom to never used (Sutphin, 1984). Malpiedi, Papritan, and Lichtensteiger (1985) discovered that Ohio teachers used commercial farm manangement programs most frequently for instruction and Henderson (1985) concurred that Illinois teachers were using agriculture related software programs more than other applications.

Beyond the status of microcomputer use and desired competencies, few studies have investigated the barriers to using computers in terms of the user's attitude toward computers. Henderson (1985); Malpiedi, Papritan, and Lichtensteiger (1985); and Foster and Miller (1985) indicated that barriers to computer use included expensive software, access to computers, lack of computer teaching materials, and lack of computer knowledge. Wiggins and Trede (1985) studied the influence of student characteristics on achievement in a computer programming class. They concluded that mathematic ability was one of the prime indicators of computer achievement. While microcomputer ownership, formal computer instruction, and programmable calculator experience did not significantly influence student achievement, prior computer experiences tended to influence student attitudes toward computers which in turn influenced student achievement. While numerous barriers have been identified, all have the potential for impeding the use of microcomputers and also serve as blocks toward developing a positive attitude toward computer.

Teachers and students generally have a positive attitude toward using computers (Jay, 1981; Marshall & Bannon, 1985). However, Norris and Lumsden (1984) quickly pointed out that educators seem to be positive about computers as long as the function of computers was removed from their classrooms. Komoski (1984) and Montag, Simonson, and Maurer (1984) contended that computer anxiety was a viable barrier to the use of computers by students, teachers, and administrators. Individuals who experience cyberphobia, the fear of interaction with computers, rarely enrolled in computer courses (Cowlishaw, 1986). However, enrollment in university computer classes was significantly increased after Cowlishaw conducted short courses for those who exhibited high levels of computer anxiety. Wiggins and Trede (1985) concluded that students who were self-motivated to enroll in their computer class had a more positive attitude and performed better than those who were not self-motivated.

Need for the Study

The National FFA computer study revealed that only 5% of the vocational agriculture departments in North Carolina were using microcomputers in 1984. Over the past three years, the number of microcomputers in the schools has increased. The North Carolina State Department of Public Instruction has identified required computer competencies for all educators and competencies for educators related to their content areas. However, during the same three year period, only one on-campus university computer course and three state-sponsored workshops have been offered for vocational agriculture teachers. No formal plan for computer education has been developed. There is a lack of evidence as to which teachers are using microcomputers, how they are using them, and what barriers--particularly attitudinal barriers--still impede the adoption of microcompters by the teachers. Before systematic microcomputer instruction can be conducted in the state, this study is needed to address these concerns.

Purpose and Objectives

The purpose of this study was to determine the degree of microcomputer use and the computer attitudes of North Carolina vocational agriculture teachers in order to more effectively deliver computer education. A secondary purpose of the study was to explore possible relationships between teacher characteristics and computer anxiety levels, a measure of computer attitude.

Research questions answered by the study were as follows:

1. How much computer educational training and experience did the teachers possess and what were the relationships of prior education with computer use?
2. To what degree were teachers using microcomputers, particularly as a tool for teaching, for class preparations, and for other school and-personal related work?
3. What computer anxiety levels were exhibited by the teachers and how did the mean level compare to national norm?
4. What charateristics were associated with computer anxiety levels ?
5. What were the computer educational needs of the teachers ?

Methods and Procedures

The study was of the descriptive research type. Descriptive research studies are designed to obtain information concerning current status of phenomena (Ary, Jacobs, & Razavieh, 1985). This was a survey study with the major purpose of describing selected characteristics and exploring possible relationships by employing correlational techniques (Isaac & Michael, 1983).

The Sample

A population of 372 teachers was identified from the *1985 - 1986 North Carolina Directory of Vocational Agriculture Teachers*. Revisions including teacher retirements and position changes as noted by the State Department of Public Instruction were used in determining the accurate number of current teachers as of August 1, 1986. Sample size was calculated from the Krejcie and Morgan (1970) formula so that the sample proportion p would be within ± .05 of the population proportion P with a 95% level of confidence. A sample size of 189 teachers was required for the study. Each member of the population was assigned a three digit number. Using a table of random numbers and a random start, the 189 participants for the study were drawn.

Instrumentation

The survey used in this study consisted of two parts. The first part elicited demographic, academic, and computer training information from the respondents. The North Carolina State University Agricultural Education faculty reviewed Part I to establish the content validity of the instrument. Revisions to improve readability were made. A five point Likert-type scale was adopted from instrumentation validated by Herring to measure degree of computer use. Points of the scale were defined as: 1 = very rarely, 0 > 1 hrs/day; 2 = rarely, 1-2 hrs/day; 3 = some, 3-4 hrs/day; 4 = often, 5 - 6 hrs/day; 5 = very often, 7 + hrs/day.

The second part of the survey was the Computer Opinion Survey (Maurer & Simonson, 1984) used to measure computer anxiety levels by obtaining a computer anxiety index (CAIN) score. The instrument consisted of 26 computer attitude statements, such as "Computers are too complicated to be of much use to me", to which respondents indicated their agreement, 1 = strongly agree to 6 = strongly disagree. A raw score from 26 to 156 was divided by 26 to obtain the CAIN score. The lower the score, the lower computer anxiety and more positive the attitude. Reliabilty estimates were as follows: the test/retest coefficient of stability was .90 and the Cronbach's coefficient alpha measuring internal consistency was .96.

Administration

The surveys were administered by the researchers in August at the1986 North Carolina Vocational Education Workshop. Surveys were mailed to those teachers included in the sample who did not complete a survey at the workshop. Two follow-up mailings of the surveys were done at two week intervals. Miller and Smith (1983) discussed several techniques for handling non-response error, one of which was comparing early and late respondents. Since research has shown that late respondents are similar to non-respondents, one way to estimate the nature of replies of non-respondents is through late respondents. Third round respondents were treated as late respondents. No statistical differences were found on selected variables between conference participants (early respondents) and late respondents. The technique was also chosen in order to dispell any suspicion that there were differences between those who did and did not attend conference. Finding no differences, the researchers were justified in generalizing from the respondents to the sample. One hundred sixty-three teachers returned completed surveys for an 86% return rate.

Data Analyses

The *StatView* microcomputer program (Feldman & Gangnon, 1985) was used for the data analysis. Measures of central tendency, distribution, frequencies and/or percentages were reported to describe demographic, academic, computer educational training, amount of computer use, and professional characteristics. Data were examined and met the necessary assuptions thus permitting the researcher to use relational statistics. Correlation coefficients appropriate to the data level were used to explore the relationships between the respondents' characteristics as well as degree of computer use and the respondents' CAIN scores. In order to explore relationships between nominal data and CAIN scores, the scores were grouped as high (greater than one standard deviation above the mean), moderate, and low (greater than one standard deviation below the mean) anxiety scores. The alpha level was set at .05 a prior. Davis Conventions (1971) were used for the interpretation of the strength of the relationships. The conventions used were as follows:

Coefficient	Description
.70 or higher	Very strong association
.50 to .69	Substantial association
.30 to .49	Moderate association
.10 to .29	Low association
.01 to .09	Negligible association

Limitations of the Study

Conclusions of the study were limited to those who were identified as vocational agriculture teachers in North Carolina for the 1986 - 1987 school year as of August 1, 1986. The study represented a "slice of time" and what was true for that time period. The researchers can not control local school system activities which might include the sudden infusion of microcomputers and microcomputer instruction locally. Therefore, the results of the study must be regarded as short term. Survey research is also dependent on the honest reporting of the participants and data were interpreted with that assumption in mind.

Findings

Demographic, Academic, and Professional Characteristics of the Sample

Ninety-five percent of the respondents were male. The age groups of the respondents included: 21-30 years (26.54%); 31-40 (33.33%); 41-50 (19.14%); 51-60 (19.14%); and over 60 years (1.85%). All respondents held college degrees with 97 bachelor, 63 masters, 2 associate, and 1 six year degrees. College math grades earned by the respondents (A=4 points) were reported by the respondents to be mostly Bs (47.85%), followed by Cs (39.88%) and 12.27% were As.

Most of the teachers were production agriculture teachers (41.72%). Others primarily taught horticulture (29.45%) followed by agriculture mechanics (14.11%), introduction to ag/natural resources (8.60%), forestry (2.45%), natural resources (2.45%), prevocational (.61%), and other (.61%).

Computer Experience and Education

Only 89 (54.6%) teachers have ever used microcomputers. Of those who used computers, Apple computer was the predominant brand used (35.58%) followed by Radio Shack (14.72%). Eleven percent of the teachers actually owned a microcomputer.

A lack of formal computer course training was evident as 122 or 74.85% of the teachers had never taken a college credit computer course. Thirty teachers or 18.40% completed one semester course, eight (4.91%) completed two semester courses, and three (1.84%) completed 3 semester courses. On the other hand, 109 (66.87%) indicated that they had participated in computer workshps or inservice activities, while fifty-four (33.13%) teachers had not. The mean number of hours spent workshops/

inservice was 9.62 hours with a standard deviation of 12.56, a range equal to 70, and a median of 4. The positvely skewed distribution indicated that while the teachers had computer training, the amount of training for the most part was very limited.

Was there a relationship between computer education and hours of computer use by the teachers ? As shown in Table 1, there was a significant moderate association between the number of computer courses taken and the number of daily hours the teachers use computers. A significant low association was found to exist between the number of workshop/inservice hours completed and the number of daily hours the teachers used computers.

Table 1

Relationships Between Types of Computer Education and Computer Use

Type of Computer Education	Hours of Daily Computer Use
University computer courses	.323*
Hours of workshop/ inservice computer training	.291*

Note. Relationships determined by Pearson Product Moment Correlation Coefficient, Pearson r.
*p < .01

Educational Computer Uses

On the average, teachers used microcomputers .55 hours per day with a standard deviation of 1.31. In terms of specific uses, of those who used computers, 36.20% used them as a teaching tool (CAI); 32.51% for school related and other personal work, applications i.e. correspondence, inventory, budgets, etc.; and 28.22% for preparation of course materials, student grades (CMI).

Teachers perceived that managing student information was the most important use for microcomputers (Table 2). That use was followed by teaching, nonstudent school related work, networks, personal management, and entertainment. When the rankings of those teachers who used computers was compared to the rankings of those who did not use computers, the orderings of the uses were identical.

Table 2

Rank Ordered Means of Perceived Use for the Microcomputer in Education

Rank	Computer Use	Mean
1	Managing student information (grades, SOE records,etc.)	2.26
2	Teaching students (tutorials, simulations, ed games,etc.)	2.50
3	Nonstudent school related work (letters, reports, mail list, etc.)	2.81
4	Networks (Agri-Data, CompuServe, etc.)	3.85
5	Personal management (budget, taxes, etc)	4.00
6	Entertainment (non ed game)	5.51

Note. Respondents ranked the uses from 1 = most important to 6 = least important.
n = 163

Computer Attitude and Anxiety Levels

Teachers tended to be more positive toward using computers than negative. Out of a possible 156 points, scores ranged from 26 to 132, with a mean of 64.45, standard deviation of 21.39, median equal to 61.5 and a mode of 39. The converted mean CAIN score for the teachers, obtained by dividing the raw score by 26, was 2.48 with a standard deviation of .82, Md = 2.36, and Mo = 1.5. No statistically significant or practical difference was found between the North Carolina teachers' mean score, 2.48, and the national norm group mean for teachers, 2.44 ($t = .597$, $df=159$, $p < .375$).

Relationships Between Selected Characteristics and Computer Anxiety

Statistically significant ($p <.01$) moderate negative associations were found for the relationships between computer anxiety and the following characteristics: daily hours of use, $r = -.361$; degree of computer use as a teaching tool, $r = -.381$; degree of computer use for course preparation, $r = -.367$; degree of computer use for other school and personal use, $r = -.387$. As the degree of computer use increased, anxiety levels decreased. Low significant negative relationships were found between the number of computer college courses taken and anxiety scores (r= -.192, $p < .05$) and between the number of workshop/inservice hours and anxiety scores (r= -.243, $p < .01$). It follows that as computer education increased, computer anxiety scores decreased.

Age and ones computer anxiety score are not independent (X2 = 15.277, C.V.=12.59, df=6, $p < .05$). A statistically significant ($p < .01$) positive low association existed between age and computer anxiety (Cramer's V = .219). College math ability was independent of the anxiety score (X2 = 7.132, C.V.= 9.49, df=4, $p < .05$). A low association between math ability and computer anxiety scores (Cramer's V = .149) was not significant. The area of teaching - production agriculture, horticulture, agricultural mechanics, and others combined - was also independent of the anxiety score (X2 = 5.178, C.V.=12.59, df = 6, $p < .05$). A low association, Cramer's V = .127, was found but not significant.

Computer Educational Needs

Computer attitudes and educational needs of teachers by districts are displayed in Table 3. Only 42.94% of all responding teachers indicated interest in participating in credit computer courses while 65.64% were interested in computer workshops. State staff members were interested in knowing the frequency and percentage of teachers per vocational education district who desired computer courses and/or computer workshops. The mean computer anxiety level held by teachers in that district provides an indication as to the computer attitudes held by teachers in those areas of the state. There was no relationship between the teachers' anxiety score and their desire for computer courses, Cramer's V = -.173. A low negative relationship that was statistically significant did exist between the teachers' anxiety scores and their desire for workshops (Cramer's V = -.212, $p < .01$).

The teacher computer attitudes in North Carolina tend to be more positive in the central part of the state - districts 3,4,5, and 6, than in the western area - districts 7 and 8 or the eastern and southern coastal areas - district 1 and 2. Teachers in district 1 tend to be negative toward using computers although 50% are receptive to courses and 57% to workshops. Teachers in district 7 and 8 had higher mean anxiety levels than other teachers but both had more low scores than high. At least 50% or more of the teachers in districts 3,4, and 8 desired computer courses. The desires for workshops were strongest for districts 2,4,5, and 6.

Table 3

District Computer Anxiety Levels and the Teachers' Desire for Courses and Workshops

	Teachers		Anxiety Level			Desire		Desire	
District	(n)	Mean	SD.	Md.	Mo.	Course(f)	%	Wkshs (f)	%
1	14	2.50	1.00	2.61	3.69	7	50.0	7	50.0
2	26	2.52	.54	2.40	-	5	19.2	22	84.6
3	30	2.46	.72	2.43	2.73	16	53.3	16	53.3
4	28	2.26	.68	2.19	-	16	55.2	19	65.5
5	15	2.32	.84	2.11	1.50	6	37.5	13	81.3
6	15	2.39	.85	2.04	1.73	6	40.0	11	73.3
7	20	2.77	.98	2.90	2.00	8	40.0	11	55.0
8	13	2.74	1.20	2.33	1.50	6	53.8	7	58.3

Note. Total number of respondents, n=161. Percentages do not total 100%; they represent percentages of teachers in each district responding yes to courses and to workshops.

Conclusions

Based on the findings of the study, the following conclusions relevant to North Carolina vocational agriculture teachers were warranted:

1. Computer education for North Carolina vocational agriculture teachers has not occurred to a great extent. With additional education, teachers should increase their microcomputer usage.
2. Although there is limited computer use by the teachers, they identified important uses of the microcomputer as a management and teaching tool, consistent with the literature.
3. Teachers' attitudes toward computers are generally positive and do not differ from the national norm. With increased computer use, the anxiety levels felt by computer users should diminish.
4. As higher anxiety levels are associated with increased age, computer workshop/course instructors need to be sensitive to providing successful experiences for all, especially older students. On the other hand, math ability and teaching area were not associated with computer anxiety levels and should not be viewed as indicators of computer anxiety.
5. Teachers are most likely to participate in

computer workshops and secondly, courses even though higher computer anxiety levels are associated with the desire for computer workshops.

Recommendation

1. A systematic computer education plan should be developed and implemented immediately since computer use is associated with computer education. Short workshops or other positive experiences with the computer should be developed for those teacher who have scored high on the anxiety index.
2. Computer courses and workshops should continue to emphasize using the computer as an instructional and as a management tool in the classroom.
3. The Computer Opinion Survey should be administered before instruction as it provides a useful indication as to which students need the most help in diminishing negative computer attitude barriers.
4. Further research should be conducted to investigate those characteristics which are the best predictors of computer anxiety.
5. Further research needs to be conducted to determine how various instructional techniques affect computer attitude and learning.

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Energy Literacy: The Changing of Cocksure Ignorance to Thoughtful Uncertainty

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The Energy Dilemma

Energy is classically defined as the ability to perform work. This definition in itself is somewhat isolated until the implications are examined from several standpoints of relevance. Energy basics dictate that our supply of this commodity is derived through "energy conversion" techniques that are utilized to convert fossil fuels, solar, and nuclear energy into ultimately useful forms. These forms of useable energy manifest themselves in the actual production of goods and services which is the total gross national product of our society as we know it. Therefore, it is imperative that *all* persons within our society be "energy literate" to some degree. Furthermore, since energy directly affects our standard of living, industrial productivity, economic well being, and a host of other related factors, those persons involved in technical education have a tremendous opportunity and obligation to include "energy literacy" in their hierarchy of educational objectives.

An acute energy awareness was brought about by the Arab oil embargo during which time Americans lined up to purchase a dwindling supply of higher priced fossil fuels to power their automobiles. Government reacted by initiating tax credits for solar home systems, lowering vehicle speed limits, preaching energy conservation, and a host of other measures designed to ultimately render us "energy independent" as a nation. During which time many thought that our energy problems would be answered by a scientific miracle while others assured us that solar energy was really the answer and that there was enough "free" energy from the sun for our society to once again flourish as we always did. Other more exotic energy answers were advocated in the forms of geothermal energy, wind farms, biomass techniques, conversion of vegetation to alcohol, and others. Many Americans discussed these as they "topped off" their automobile gasoline tanks at every opportunity.

The industrial reaction during the 1970's was somewhat more definite and constructive. Many industries converted oil-fired systems to coal and adopted cogeneration and heat recovery systems where practical. Some of our industrial manufacturing segments, such as those engaged in plastics and petro-chemicals, had little choice and raised their pricing in order to reflect their base petroleum costs. There was also much talk about synthetics and other substitutes deemed possible to alleviate the fossil fuel extractives. However, the vast majority of these schemes never materialized and were shelved with a sigh of relief as OPEC floundered in disagreement over oil pricing and production quotas. In short, we opened our pocketbooks a little wider, purchased enough petroleum from abroad to conduct business, and stuck our heads in the sand.

The Reaction of American Education

The Russians launched their first satellite "Sputnik" in 1957. This launching created a mammoth effort to overhaul American education and align curricula with increased math and science requirements. Congress endorsed efforts to fund these educational improvement thrusts at a level unprecedented by today's standards. Engineering curricula was revamped to include increased mathematics and more abstract design content to enable engineers to cope with the demands of the aerospace industry. In fact, this led to a design oriented, highly abstract engineering graduate that had difficulty contributing to manufacturing industry upon graduation without a substantial and costly "in-serve" training period. Henceforth, engineering technology was born to fill this void.

Other reactions to the Russian "Sputnik" were the revision of textbooks, reviewing and equipping laboratories, and a general endorsement of any activity that might support science, math, or engineering. Industrial arts, vocational education, and other technical education students could even be seen tinkering with small rockets both inside and outside the laboratory.

In retrospect, American education reacted to the demands of aerospace during a demonstrated time of need. However, the crisis of energy in America has largely been ignored even though its implications are equally as important. The science curricula is probably addressing energy education more so than is technical education. However, science does include the introduction of energy units such as Joules, BTU's, watts, and the like in a rather fragmented manner. This results in the science student not understanding the American energy picture as a whole. The world energy crisis to typically not addressed whatsoever by the exact science curriculum nor the social science programs within our schools. Furthermore, an analysis of the various national directories of industrial teacher educators reveals that less than thirty (30) technical educators indicate "energy" as a part of their teaching repertoire or area of expertise. It is therefore evident that energy education is presently not an organized thrust within American education.

Energy Literacy Instrument

The author constructed instrument included within the body of this paper was designed to ascertain the level of energy literacy of educators. This instrument was administered to the following groups during the period May 1985 to March 1987:

1. 120 baccalaureate aspiring college students enrolled in technical education academic majors.
2. 48 public school teachers of science, math, and social science currently teaching in the southeastern U.S.
3. A cross section of 30 vocational teachers currently employed within the southeastern U.S.
4. 62 senior citizens enrolled in the national Elderhostal program from throughout the U.S.

The results of the administration of the energy literacy instrument to the previously cited groups was less than gratifying, however, they did confirm the fact that all groups were indeed not energy literate as measured by the instrument. It was interesting to note that no one single group scored significantly better comparatively speaking. However, the 120 college students scored best with a grand population mean raw score of 41.2 percent. The population mean raw score of all participating groups was only 39.4 percent. The group of 30 vocational teachers scored lower than all other groups with a population mean of 36.4 percent.

Through discussions, many of the individuals within the tested groups indicated that they guessed at many test items and that energy was not a part of their educational preparation.

This author offers the aforementioned "Energy Literacy Survey" as an integral part of this paper. As educators, perhaps through the process of introspection, the void of energy literacy within technical education is best illustrated by *your* personal reactions.

ENERGY LITERACY SURVEY

INSTRUCTIONS: PLEASE DO NOT WRITE ON THIS INSTRUMENT--USE ANSWER SHEET FOR ALL RESPONSES.

Respond to the energy related items contained herein to the best of your ability. Please *do not guess* if you have insufficient knowledge to respond to a particular item. In such instances, indicate your lack of knowledge by selecting choice "5" which is labeled "?". This energy literacy survey has *no effect on your grade.*

1. Which segment of our society utilizes the most energy?

   1. Residential
   2. Commercial
   3. Industrial
   4. Transportation
   5. ?

2. Most of our electrical energy is presently produced from:

   1. Water power
   2. Oil
   3. Coal
   4. Nuclear
   5. ?

3. The electrical energy you consume in your home is billed or sold to you in what units?

   1. Watts
   2. Kilowatt hours
   3. Amperes
   4. Volts
   5. ?

4. Which of the following home electrical appliances consumes the greatest amount of energy on a monthly basis?
   1. Television
   2. Refrigerator
   3. Hot Water Heater
   4. Electric Range/Stove
   5. ?

5. Which statement is true?
   1. Coal accounts for most of our known reserves of fossil fuels
   2. Coal produces less air pollution than oil or natural gas
   3. We use more coal than oil or natural gas
   4. We must currently import massive amounts of coal
   5. ?

6. Which energy source is used to produce more than half of our electricity?
   1. Coal
   2. Natural gas
   3. Oil
   4. Nuclear
   5. ?

7. Which of the following fuels has more energy per unit volume?
   1. Alcohol
   2. Gasoline
   3. Diesel Fuel
   4. Wood
   5. ?

8. Which of the following terms relates to the rate that work is done?
   1. Energy
   2. Joules
   3. Power
   4. Calories
   5. ?

9. Which fuel became our leading source in the 1880's and played a major role in powering our industrial revolution?
   1. Wood
   2. Coal
   3. Oil
   4. Manpower
   5. ?

10. Which energy source heats more than half of the homes and apartments in the U.S.?
    1. Heating oil
    2. Natural gas
    3. Electricity
    4. Wood
    5. ?

11. Two of the statements below are correct, which is incorrect?
    1. Under normal operating conditions, nuclear plants release only a very small amount of pollution into the atmosphere.
    2. Nuclear energy is used commercially for only one purpose: to produce electricity.
    3. The major problem for the nuclear industry has been a poor long term safety record.

12. Solar hot water collectors on the roof of a house are an example of which solar energy form?
    1. Direct solar heating
    2. Indirect solar heating
    3. Solar-thermal conversion
    4. Thermosiphon Principle
    5. ?

13. Which If a potential source of large amounts of liquid fuel for transportation?
    1. Geothermal energy
    2. Shale
    3. Nuclear Fusion
    4. Peanut oil
    5. ?

14. Which source makes no contribution whatsoever to our energy supply?
    1. Wind
    2. Solar
    3. Nuclear Fusion
    4. Fossil Fuels
    5. ?

15. How much of our total energy supply is used to produce electricity?
    1. Less than 20%
    2. 35%
    3. 50%
    4. 70%
    5. ?

16. How much of the energy consumed in the U.S. each year is used in the transportation sector?
    1. 25%
    2. 50%
    3. 70%
    4. 90%
    5. ?
17. Which of the following electrical appliances is most efficient?
    1. Stove
    2. Refrigerator
    3. TV
    4. Hot Water Heater
    5. ?
18. Which fuel became our leading energy source in 1950 and remains so?
    1. Natural gas
    2. Wood
    3. Oil
    4. Nuclear energy
    5. ?
19. What was the cost of foreign oil to the average American family in 1980?
    1. $100
    2. $400
    3. $600
    4. $1500
    5. ?
20. What is the leading product made from oil?
    1. Heating oil
    2. Gasoline
    3. Electricity
    4. Lubricants
    5. ?
21. Which of the following woods contains more heat energy?
    1. Wet pine
    2. Dry pine
    3. Wet oak
    4. Dry oak
    5. ?
22. Which solar technology is most practical in cost today?
    1. Solar cells
    2. Solar power towers
    3. Solar space heating
    4. Solar water heating
    5. ?
23. Which is the most economical speed for an automobile?
    1. 10 mph
    2. 40 mph
    3. 55 mph
    4. 60 mph
    5. ?
24. Which of the following does *not* cause your car to use more gasoline?
    1. Turning on headlights
    2. Speeding up
    3. Passing another car by accelerating
    4. All of the above increase gasoline use
    5. ?
25. Which is the most efficient home heating unit?
    1. Fireplace
    2. Electric Furnace
    3. Heat pump
    4. Air tight wood stove
    5. ?
26. When washing clothes in hot water, it costs more to heat the water than to operate the washing machine?
    1. True
    2. False
    3. ?
27. Fluorescent lights are about 3 times more efficient than ordinary incandescent lamps in terms of energy vs. light output.
    1. True
    2. False
    3. ?
28. Electric lighting is one of the major consumers of electric energy in the home and throughout our nation.
    1. True
    2. False
    3. ?
29. It is more energy efficient to leave electric lights turned "on" rather than to switch them "off" and use them only when needed.
    1. True
    2. False
    3. ?
30. Refrigerators and air conditioners are actually heat pumps.
    1. True
    2. False

31. What is the typical "lead time" from planning to actual production relative to an electrical power generating plant?
   1. 5 years
   2. 7 years
   3. 10 years
   4. 20 years
   5. ?

32. Concerning outside electric lighting, which of the following would be the most energy efficient in light vs. electrical power consumed?
   1. Quartz-Iodide
   2. Fluorescent
   3. Mercury Vapor
   4. High Pressure Sodium
   5. ?

33. What portion of the average household energy bill is attributable to domestic hot water heating?
   1. 30%
   2. 15%
   3. 7.5%
   4. 52%
   5. ?

34. Man-made radioactive materials are more dangerous than those that occur in nature per unit of measure.
   1. True
   2. False
   3. ?

35. A coal fired electric generation plant produces no nuclear radiation pollution but may have undesirable air emissions.
   1. True
   2. False
   3. ?

36. One watt of electrical energy is equal to about _____ BTU's of heating capacity?
   1. 3.14
   2. 1.0
   3. 6.25
   4. 1,000
   5. ?

37. How many electrical watts are equal to one horsepower?
   1. 1,000
   2. 235
   3. 978
   4. 746
   5. ?

38. Solar energy is safe and completely nonpolluting.
   1. True
   2. False
   3. ?

Energy Technology for Technical Educators

Since it has been demonstrated that energy education and literacy is not presently being included within the framework of teacher-education or vocational teacher preparation, it is proposed by this author that such content be adopted. Also, since energy literacy is desirable for all, technical education could serve as the vehicle for the insertion of energy education into the curricula of vocational, technical, and other industrial education instructional offerings. This can be viewed as a tremendous opportunity as well as an obligation insofar as energy education is not being presently addressed on an organized basis by an educational sector.

Traditionally, vocational education has been of "less than college" grade. However, in many areas of the country, this is rapidly changing to render vocational-technical schools to the status of college credit granting institutions. This change will mandate mammoth changes in vocational faculty preparation and the accreditation standards and procedures applied to such institutions. This new role for vocational education could better allow it to offer such relevant "spin-off" occupational training related to energy such as "energy management" or "energy instrumentation." It is obvious that inservice vocational teacher training will be required if energy education is to be included.

Energy Education Topic Recommendations

This author proposes the following topical energy education outline for inclusion within those technical education segments, vocational or not, that choose to include such. There is no claim for completeness or uniqueness of content insofar as each individual topic can be expanded or further subdivided.

In your perusal of the proposed energy education topic outline, please mentally review the following objectives of this paper by answering the following questions:

1. Do you consider yourself energy literate?
2. Do you think our educators should be energy literate?
3. Should vocational education serve the cause

of energy education?

4. Is energy education important to all?
5. Who, if anyone, is presently serving energy education needs?

PROPOSED ENERGY TOPIC SUBJECT OUTLINE

I. Basic Energy Concepts
  A. Energy-Definitions and Types
  B. Work
  C. Power
  D. Energy Conversion
  E. Laws of Energy Conservation-Enropy
  F. Energy Units and Conversions

II. Energy Consumption and Utilization
  A. World Energy Consumption
  B. U.S. Energy Consumption
  C. Energy Consumption vs. Industrial Productivity
  D. Sectors of Society as Energy Consumers

III. Fossil Fuel Energy-Derivation, Conversion Distribution
  A. Oil
  B. Coal
  C. Natural Gas
  D. Electricity

IV. Solar Energy
  A. Photovoltaics
  B. Direct Solar
  C. Indirect Solar

V. Other Energy Sources and Alternatives
  A. Nuclear
  B. Biomass
  C. Thermal
  D. Wind
  E. Tidal Power
  F. Wood

VI. Social-economic Implications of Energy
  A. Industrial Productivity
  B. Gross National Product vs. Energy
  C. Per Capita Energy Utilization: State, National, World
  D. The Food-energy Equation

VII. Energy Conservation
  A. History of Energy Use
  B. Energy in the Home
  C. Energy Related to Transportation
  D. Conservation Measures

Florida's Assessment of Vocational Teachers' Training Needs: The First Step in a Five-Year Statewide Inservice Plan

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Introduction and Background

The quality of education is largely dependent upon the professional competence of those who deliver it. In vocational education, this competence is closely related to currency of knowledge. Technological changes are particularly acute in vocational education, where advances in the workplace are rapid and have an immediate impact on curriculum and instruction. Thus, maintaining technical currency among vocational teachers is of paramount importance.

The vocational staff development issue in Florida in 1985 was to determine how the State could do a better job of helping vocational teachers keep up-to-date technically and professionally. The legislature responded by passing, as part of the Teacher Education Center Act, a mandate for the Department of Education to develop a five-year statewide master inservice plan for vocational education.

The plan was developed according to the outcomes of an invitational conference and the overall recommendations of hundreds of individuals from diverse groups. It was the consensus of these groups that the plan should:

1. Be a plan of action, rather than a report of what exists,
2. Briefly report on the current status of vocational inservice to illustrate the need for a new approach,
3. Recognize the worth of existing systems in place and build upon them,
4. Include plans of action with specific goals, objectives, activities, timelines, and resources, and
5. Be developmental in nature and use formative evaluation as a part of implementation.

The master plan itself took on an identity when it was named the *F*lorida *I*nservice *V*ocational *E*ducation Plan. . .The FIVE plan.

Organization of the Plan

The FIVE Plan contains seven main sections within the three phases of Development, Implementation, and Evaluation:

DEVELOPMENT

1. Coordination
2. Needs Assessment and Priorities

IMPLEMENTATION

3. Delivery Strategies
4. Involvement of Business, Industry, and Other Employers
5. Certification
6. Resources

EVALUATION

7. Data Collection and Monitoring

Each section contains a goal, an overview, a narrative of the proposed plan, and finally a plan of action in chart form.

Status of the Plan

The plan was submitted to the State Board of Vocational Education and received provisional approval at its meeting of July 1, 1986. Full acceptance was contingent upon the following provisions: (1) an inventory of all existing inservice activities and resources would be compiled; (2) an assessment of inservice training needs among vocational instructional personnel would be conducted; (3) regional public hearings would be held on the plan; and (4) the plan would be revised based upon these activities.

The plan itself had called for conducting a needs assessment and an inventory of inservice activities and resources. However, with the State Board requesting these activities their credibility and importance was strengthened.

A. *Inventory of Inservice Activities*

In March, 1987 the statewide inventory of inservice activities and resources was completed. Data for all 28 community colleges and 59 of the 67 public school districts were collected. The inventory document clearly shows where technical updating is not receiving much emphasis at the district and community college level. Out of the 16,609 persons participating in inservice, 53% of them were engaged in professional updating activities vs. 43% in technical updating activities. (NOTE: the 16.609 figure is not unduplicated persons, i.e. an individual teacher may have been counted several times to reflect each updating activity experienced by the teacher.) Four percent of the activities were classified as a combination of professional and updating activities. The data, which described 1985-86 activities showed that a total of $1,741,241 was spent by Florida schools to update their vocational teachers. Table 1 summarizes the resources expended.

Table 1. Florida Inservice Dollars Spent for Vocational Teacher Updating (1985-86)

Inservice Activity	Federal $ Spent	State $ Spent	Local $ Spent	Other $ Spent	Totals
Prof. Updating	$197,863	$ 411,228	$140,445	$55,459	$ 804,994
Tech. Updating	59,486	684,195	96,685	18,976	859,343
Both	56,304	16,624	3,581	395	75,904
Totals	$313,653	$1,112,047	$240,711	$74,83	$1,741,241

B. *The FIVE Plan Needs Assessment*

The needs assessment was conducted between August and October of 1986. All vocational teachers in Florida school districts, community colleges, and correctional institutions were given an opportunity to indicate the extent of technical and professional updating they desired.

One hundred percent of the community colleges and correctional institutions and ninety-four percent of the school districts participated in the voluntary survey.

The statewide results of this needs assessment have been compiled by Florida State University for the Division of Vocational, Adult, and Community Education. The Division has used them to establish priorities for allocating federal dollars to provide inservice training.

Local and regional reports were distributed to all Local Education Agencies (LEAs) for their use in setting local staff development priorities.

Essentially, the needs assessment consisted of two instruments designed to identify teacher-perceived needs for (1) professional updating and (2) technical updating.

1. *The Professional Needs Assessment*

The professional needs assessment was entitled: "The Vocational Self-Assessment Inventory" and was a stream-lined version of a needs assessment developed through a study by Dr. Roger Kaufman at Florida State University.

Instructors were asked to rate their ability to perform specific tasks related to competency-based instruction and dealing with special needs students. They were also asked to rate the importance of the task based on the following rating scale.

Rating Scale Ability to perform tasks:

0 = Not Able 2 = Adequately Able

1 = Somewhat Able 3 = Confidently Able

Importance to you:

0 = Not Important 2 = Important

1 = Low in Importance 3 = Extremely Important

Computer analysis of the data from the instrument generated printouts which described respondents average ability and perceived importance for teaching competencies clustered along these dimensions:

A. Implementation for Instructors/ Administrators
B. External Needs Assessment
C. System Planning
D. Instructional Planning
E. System Development
F. Resource Determination and Procurement
G. System Evaluation and Revision
H. Special Needs

Part of the analysis included the calculation of the difference between the Ability and Importance ratings, called the *differential*. It was suggested that planning inservice activities might take into consideration differential figures that described teachers perceived low ability to perform a competency that was judged of high importance. Competencies judged to be of low importance and/or perceived high ability by teachers would not be caused to plan inservice on that topic.

2. *Technical Updating Needs Assessment*

The instrument that was designed to assess the technical updating needs of Florida's vocational instructors was entitled: "The Vocational Education

Inservice Training Request for Technical Updating."

The technical training needs assessment of instructors was based upon the mandated curriculum standards. In Florida, statewide Curriculum Frameworks and Student Performance Standards have been adopted by the State Board for Vocational Education pursuant to Florida Statutes.

Through these standards do not dictate specific techniques or instructional methodology, they must be adhered to by schools in planning, implementing and evaluating vocational courses and programs. The extent to which these standards are adhered forms a primary basis for program review and evaluation. The standards are revised and updated annually based upon changes in occupations utilizing input from business and industry employers, licensing and crednetialing agencies, professional associations, and other representatives of the private sector.

Technical updating needs related to specific Performance Standards and Intended Outcomes of the Vocational Curriculum Frameworks were collected through the "Vocational Education Inservice Training Request for Technical Updating" form. Teachers were asked to respond with the amount of training they desired for each intended outcome in the curriculum framework(s) for their program(s). The rating scale used was:

0 = no training desired 2 = moderate training desired

1 = a little training desired 3 = much training desired

A number of different reports were generated by the computer for state, regional and local use. For instance, one set of reports was prepared that summarized the perceived training needs across all Intended Outcomes for all teachers who responded statewide in a particular vocational program.

Another type of report was provided for each vocational program which showed the average training needs among instructors for each intended outcome in the program's Curriculum Framework. These reports aggregated the data statewide, by districts, by community college and even by individual high school when applicable. The reports have been especially useful to state and local staff developers and vocational personnel in planning specific inservice activities. They have also been helpful in conducting joint planning efforts between various districts and institutions. The needs assessment data provided information about teachers' perceived needs directly related to classroom instructor and has consequently made inservice more relevant to these needs.

Results of the needs assessments for individual schools, districts, community colleges, and correctional institutions were disseminated through five regional meetings held in February. A complete training package entitled: "Guidelines for Using the FIVE Plan Needs Assessment Data," was developed by the Center for Instructional Develoment and Services at FSU to assist LEAs in getting maximum utilization of the needs assessment results. In addition, the results were disseminated to state level Occupational Program Specialists through a series of workshops. These workshops focused on developing and using guidelines and criteria for setting priorities for training in the various vocational program areas. Appendix F lists the criteria that was used for setting statewide training priorities.

Although it is still too early to say exactly how useful the FIVE Plan needs assessment has been, several significant activities have occurred:

1. Most, if not all, RFP staff-development dollars have been allocated based on the needs assessment results;
2. A $300,000 sabbatical program for vocational teachers has been operationalized and applicants' needs were validated using the assessment;
3. Virtually all tecnical updating activities planned for Florida's Annual Statewide Vocational Conference will be based on the needs assessment;
4. All federal staff development dollars in vocational education *must* now be used for technical updating;
5. There is some evidence of regional planning or consortium arrangements materializing as a result of common needs having been identified; inservice activities are being jointly planned between neighboring districts and/or community colleges; and
6. Bridges are being built between vocational directors and district staff developers in order to meet the updating needs of vocational teachers.

What are some of the technological training needs in Florida that might be of interest to this symposium? Let's look at the top two priorities identified on a program-by-program basis:

Table 2

Florida's Top Statewide Technical Updating Inservice Priorities for Vocational Teachers (1986-87)

Program Area	Perceived Updating Needs	Sample Programs Targeted
Agribusiness	Control insects, diseases, and plant pathogens	Farm Prod. Management Ag Production Ornamental Horticulture Nursery Operation
	Operate, maintain, repair equipment	Ag. Business Tech. Ag. Mechanics Ag. Production Ornamental Horticulture Nursery Operations
Business	Perform data processing activities	Accounting Operations Secretarial Clerk Typist Receptionist
	Perform decision making activities	Office Sys. & Management Word Processing Mgt.
Industrial Arts	Demon. technological literacy about industrial systems	Practical Ind. Systems
	Demon. computer literacy and application	All I.A. programs
Marketing Ed.	Role of manager and the entrepreneur	Real Estate Management Parts Marketing Restaurant Management
	Knowledge of merchandising activities	Marketing Management Real Estate Management
Health Occupations	Demon. employability skills	EMT Health Care Management Massage
	Apply Computers in Medical Tech	Health Unit Coord. Explor. of Health Occ.
Public Service	Demon. employability skills	Fire Science Tech IMTS
	Apply first aid/CPR	Correctional Officer Law Enforcement Firefighting
Diversified Occupations Education	Demon. employability skills	Diversified Cooperative Training
Industrial Education	Apply plasma arc skills	Welding
	Apply basic heat gain, heat loss, and design skills	Air Conditioning Refrigeration and Heating Mechanics
Home Economics Education	Provide for special needs of family	Home and Family Mgmt.
	Care for children with special needs	Child Dev., Guidance and Care

Reflections of the Researchers

After all the forms had been submitted, the last computer run had been completed, and the last workshops to disseminate the results were over, the research team reflected on the events of the past year. Truly some incredible things had occurred. In light of the fact that participation was voluntary, cooperation by so many schools and teachers was amazing. State-level staff are encouraged by the demonstrated desire of schools to learn about the training needs of their vocational teachers.

Still, there are measures that can be taken to improve the process, the number of useful returns, and the dissemination process. The following is a list of actions that the researchers propose to implement when the assessment is repeated.

1. Since about 12% of the responses were unusable due to erroneous information recorded on the response sheets by teachers, a verification system to provide essential information on the forms should be implemented. . .such as having local administrators validate the course, school and district identification numbers. It was impossible to check these at the state level since no teacher names appeared on the form to provide the basis to correct or enter missing information.
2. Even though forms and sample reports were field tested, as it turned out not all the reports have been found to be useful. For instance, the reports that showed data compiled by school type (e.g. all high schools, all community colleges) were not found to benefit either state or local planners. Streamlining other reports was found to be desirable and will be incorporated in the next cycle.
3. A number of person complained about the length of the professional instrument and its applicability to inservice planning. A number of the items seemed to confuse or bewilder respondents. A more thorough evaluation of the usefulness of this instrument is currently underway.
4. Results from the assessment were provided to local vocational deans and directors. However, the planning and organization of most inservice activities are typically the responsibility of others such as staff development personnel in districts. To maximize the resources available to them, the vocational administrators have to communicate

with staff development personnel. Having observed the general lack of communication between these groups, the researchers are inclined to recommend that more formal linkages be established if necessary, and joint planning be initiated within districts where it's not naturally occurring.

5. Refinements should be made in the analysis of the results. Priorities were set *within* program areas. Procedures, criteria and methods for establishing priorities *across* program areas still need to be developed and implemented. In order to set priorities across program areas and fund activities, additional data besides needs may need to be provided to decision makers. For instance, a weighting system might be developed and applied to favor programs with certain characteristics, e.g. new and emerging programs, high technology programs, programs critical to the economic development of the state or region, etc.
6. Questions whether or not LEAs are getting maximum benefits from the assessment is being explored. For instance, feedback to local agencies is limited to the printed reports provided by the state. Future assessments may explore the feasibility of providing schools with electronic access to their own data. Menu-driven software could be developed to allow districts and community colleges to merge and sort the data in many ways to provide information in planning local updating activities.

The Future and the FIVE Plan

There are other indicators that the FIVE Plan and the assessment have had an impact in Florida. Teachers may now use back-to-industry experiences such as summer work for their updating requirements for recertification. Program Reviews will now include a series of questions to determine if teaching staff have had updating experiences that meet their needs reported through the FIVE Plan needs assessment. The statewide assessment results can be used to document professional and updating needs of vocational teachers in order to acquire additional funding from the Florida Legislature and other sources so that more training activities take place.

Many examples can be found of counties and/or community colleges joining forces to pool their resources to meet common staff development needs. To assist persons planning activities, Florida has available to every district and community college an electronic communications network called the Florida Information Resource Network (FIRN), through which electronic mail, calendars or bulletin boards can be used to announce workshops, conferences, technical updating activities, etc. However, since too few administrators and staff developers have used the system, a series of training sessions in the use of FIRN should be implemented.

In addition, a new Clearinghouse for Economic Development has been established by the Department of Education to provide information to district and community college inservice planners. Information available through ACCESS (the title of the clearinghouse) describes training programs, education-business partnerships, names of individuals in the private and public sectors that can act as educational consultants, etc.

Conclusion

The Florida Division of Vocational, Adult and Community Education (DVACE) has long supported the professional and technical updating of vocational instructional personnel and believes in the value of inservice training.

The FIVE Plan was developed in the belief that current inservice programs in Florida are generally effective, accessible, and responsive to the needs of vocational educators. The important point for the future of vocational inservice in Florida is the belief that it can be improved. The legislation calling for this plan emphasized *improvement* in the current system of vocational inservice, particularly in better use of current resources, increased use of technology, and further integration of the business community into the process.

An overview of the plan will reveal that it is comprehensive--yet reasonable; practical--yet bold; and realistic--yet far-reaching. In time, it may prove to be one of the more important planning documents ever developed by the Department of Education. The DVACE believes that this plan, which is the result of a great deal of thought and communication, provides a framework for change that builds upon the successes of the past, accepts the challenges of the present, and meets the needs of the future. If Florida is to keep pace with changes in technology, information, and population, it can do no less than offer the best possible plan for improving its most valuable educational resource--teachers. It is to all these ends that the FIVE Plan has been committed.

The Impact of Computer Technology on Graphic Communication

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PART I

The Board Impact of Present and Future Computer Technology on Graphic Communication. (Boyer)

Introduction

Within the last 15 years, a near revolution has taken place within graphic communication, and that is the common use of the computer. Graphics classes at virtually all levels of the educational spectrum now use computers to some degree. My comments will be principally directed towards the drafting or engineering design portion of the graphics communication field. Several major topics such as technological literacy, hardware, software, and trends will be discussed.

Technological Literacy

The classroom at any level is the formal setting for teaching people to use computers to help perform tasks faster, more accurately, etc. It is in this setting that the terminology of both software and hardware can be presented to the students. Prior to the 1970's drafting and design was accomplished using manual techniques. During this period, large industries were using CADD (Computer-aided design and drafting), but high costs prevented the use of this equipment in schools. In the late 70's and early 80's, the introduction and wide acceptance of the PC (personal computer) level computers meant that the cost of computers had reached a level that the schools could afford. One area of graphic communication, the design and drafting area, benefitted greatly by this acceptance and the availability of computers and related software.

It is now common to visit a school design and drafting area and see students using a computer to create designs and drawings. Through this exposure to computers and computer applications, the door has been opened for students to learn the nomenclature and techniques necessary to use the computer to their advantage.

It is interesting to note that in most school or industrial settings a blend of some manual drafting and some computer assisted drafting is common. Few classes are either 100% manual, or 100% computer. However, most students will at least have had some exposure to CADD during their technology classroom experiences.

Hardware

The computer is only a tool for the professional to use to help produce more accurate work in less time than by manual methods. Many PC's are "stand-alone" computers. Others may be linked together with a host computer; this is called networking. Networking allows a person at any computer in the network to share and contribute to the common data base of information within the network.

The cost of hardware has reached a level low enough that most of the design and drafting programs can afford one or more computers for their classroom. Those who complain about lack of funds to purchase such equipment are generally trying to purchase enough computer work stations to fill a classroom all at once. Manufacturers often have special educational packages to help solve this problem.

New technology reaches the market every day. Some of the more recent developments to be accepted into common use are hard discs, laser disc technology, laser printers, color printers, the ability to make 35mm color slides from a screen image, etc.

If the past trend continues, the cost of the hardware will decrease even more, but the power, speed, and capacity of the computers will greatly increase. Within the past few years, "lap-top" computers have proven this rationale.

At several universities, students are provided computers to work on, either in an academic building, or in the student's dormitory room. Some schools require their students to purchase their own computer before enrolling in classes.

Software

When the PCs first entered the educational market, softare packages were available. Now there is an abundance of CADD software for any hardware system your purchase.

At first a knowledge of computer programming was necessary if a person was to create drawings using a computer. Then the various software packages began to emerge on the market. This user friendly software allowed the user to create drawings by selecting from a set of displayed commands that accessed internal programming. The user no longer had to be a programmer. With the introduction of icons, light pens, special keyboards, digitizing pads, etc., as input devices for this software, the commercial CADD packages are much more "user friendly."

One of the biggest problems concerning software is the length of time necessary for a beginning user to master the menu format of commands in order to manipulate the program successfully. This is often referred to as "up time." The biggest of the commercial CADD programs are so powerful that it takes a considerable number of hours to become competent enough to maneuver around the program comfortably. The cost of some of software is still very high. There is also a problem of unauthorized "pirating" of software. Site licenses are a step in the direction of solving this problem, but they rely on voluntary compliance.

Trends in Hardware

Hardware changes will be evident from a marketing standpoint. Computers will be smaller, more powerful, and have more memory. As soon as the technology of screen readability improves, the "laptop" computers will possibly replace the present PC configuration. This is true because the lap-tops will be truly a portable computer that is at least as powerful as todays PC's.

As for printers, advances will be made to improve the speed and quality of the printer output. Even more fonts of type will be available than are presently offered to the public.

The new computers will become more compatible with other manufacturer's computers. Telephone links will assume a much greater role in helping computers communicate with each other.

Trends in Software

Within the last few years software has become more powerful and easier to use. In the near future commercial CADD packages will hopefully become less expensive. The formatting of these programs must be presented in such a manner that the "up time" for the learner can be reduced considerably.

3-Dimensional modeling is presently available in existing sophisticated and expensive CADD packages. The trend will be to offer 3-D solid modeling at a more affordable price. This should become one of the next major trends.

Technological advances indicate that voice recognition is on the horizon. Some knowledgeable people predict that voice recognition will take the place of typing input into the computer within just a few years. This could be a bit optimistic on the time scale, but it should happen in time.

Some university engineering programs require their students to create their own CADD package in order that the student can custom design a CADD package that meets his/her own specific needs. However, most educators see a decline in the need to program to create technical drawings. There is such a variety of good CADD programs available that the user can employ these within a knowledge of programming. Some educators even suggest that programming will son be the nearly exclusive domain of the computer science major.

Trends in General

Some people suggest that the computer will lead to the "paperless society." Hard copies will always be needed, but data manipulation time and organization can and will become greatly enhanced.

The engineer will become very adapt at creating designs and drawings using sophisticated CADD packages.

There will become a resurgence of the need for sketching skills for engineers and designers. With good sketching skills, sketches can be used to aid in the creation of technical drawings on the computer.

2-Dimensional drawings will always have their place, but 3-dimensional drawings and graphics are just on the horizon.

Self-paced instruction will have its place in the training of people to use CADD programs for the production of drawings.

The designer will not only communicate with the computer, but via networking or phone lines, communication with other designers and engineers will be possible. The designer will also have a direct link to the machine tools used in manufacturing.

Educational environments will have more hardware and software available for students to use. The shift from manual drawing to computer drawing is inevitable. Manual drafting will become an "endangered species," but should not become "extinct."

Summary

If you think there has been a lot of change in the last fifteen years, be prepared, be flexible, and always have an open mind for new hardware and software technology. The change in the future will be several times greater than in the past.

PART II

Technological Literacy Needs in Graphic Communication. (Bertoline)

Introduction

The evolution of communications has closely paralleled the technological development of humankind. Through many years of development, drawings used as a means of communicating graphically, has evolved into a very complex system. Graphic communications is an extremely important component of many industries. The generation of graphic images is rapidly being automated through the use of computers. The use of computers for graphic communications has slowly evolved until recently. The rapid development of computers used for graphic communications has occurred because of the development of the microcomputer and related hardware and software. It is now possible to design, modify, document, illustrate, and produce camera ready copy of new products entirely with a computer. Much of this is accomplished using the graphic data base of the design produced on a computer. In addition, it is possible to control the manufacture and assembly of the product using the same graphic data base. This automation of graphic communications through the use of computers and software is commonly called CADD (Computer-aided design/drafting).

CADD in the Communications Curriculum

It is important for the technology teacher to realize the tremendous power and flexibility available to the user of a CADD system. It is also important to realize that CADD is a communications tool and should be taught as a subset of communications technology. By making it a part of the total communications technology curriculum, the full power and application of CADD will be realized by the student.

CADD is a tool used to supplement traditional tools used in designing and engineering. This might seem obvious to many, but it is important that this idea be the center of any curriculum changes contemplated by technology teachers. Do not become enamored with one particular CADD system or software to the point that the use of CADD becomes a narrow type of vocational training. If technological literacy is the goal of the curriculum then CADD simply becomes a different tool to be used for graphic communications.

If CADD is only a tool used to communicate graphically, then what do technology teachers need to know about this tool to effectively integrate it into their curriculum? The proposed method is not to teach CADD at all but to teach graphic communications using CADD as one of the tools that can be used to create graphics. This might be called the "generic" method of teaching graphics with CADD. Unfortunately this is not the method most used as evidenced by the proliferation of CADD textbooks written specifically for a certain type of CADD system. With these approaches, the CADD system becomes the focus of the curriculum and the tool becomes more important than the subject. This can be compared to the "tail wagging the dog," where the technology used to create graphics becomes more important than the human adaptive system of communications. This flies directly in the face of what technological literacy should be. If the goal is technological literacy and one of the components is graphic communications, then CADD should not be taught as a stand-alone course. It should not be taught on a single system with the focus on learning specific commands and procedures.

Integrating CADD Into Graphic Communications

What might be the best method of integrating CADD into graphic communication? For a number of reasons, the student should have a solid foundation in orthographic projection and sketching. If CADD is a tool used to create graphics, then technological literacy in graphic communications should have a CADD component. However, it should be taught as any tool is that can be used to create graphics. For example, when teaching the basics of design one of the components is the documentation of the final product. In the past, this documentation was accomplished using hand tools such as the compass, t-square, triangles, pencil, and eraser. When this was done, was the focus of the course on the use of the tools or the accepted methods of documentation? Why should this change? Some will argue that the software is too difficult and time consuming to learn. A better approach is to teach CADD first, then show

how the tool can be aplied to graphic communications.

This is a strong argument that must be carefully considered before a CADD component in graphic communications can be implemented successfully. It is true that CADD can be very difficult to learn and a slow introduction to the use of the tool may be necessary before the student becomes productive. However, this can be accomplished by following some of the same techniques used to introduce students to traditional tools. One of the first problems assigned to drafting students is to draw horizontal, vertical, and inclined lines. This is followed by circles, arcs, simple figures, and lettering. The same approach can be used with CADD. Traditional graphic concepts are introduced and reinforced with a specific drawing assignment that is chosen to meet a specific goal. Because of the complexity of even the most simple CADD programs, it is recommended that more time be spent on learning the basics of the system than would be normally spent with traditional tools.

After the basics of the system are learned by the student, the CADD system should become a transparent tool to the student and the teacher. CADD can now be used to create graphics and to introduce the student to other graphic communication topics using CADD and related software. However, there are times when it will be necessary to demonstrate how CADD is used to perform a particular task.

Related Areas Served by CADD

The topics to be discussed in graphic communications may depend a great deal upon the available hardware and software and the ingenuity of the teacher. Micro-based CADD systems are becoming very powerful devices that can be used for design, drafting, illustration, manufacturing, and publishing. This could be called CAD/CAM literacy. This can be defined as knowledge of the capabilities and applications of CAD/CAM in communications and manufacturing. Important topics to be included are: designing, wire-frame and solid modeling, design analysis functions, desktop publishing, CAM (Computer-Aided Manufacturing), robots, flexible manufacturing, CIM (Computer-Integrated Manufacturing), the factory of the future, and the social implications of these technologies.

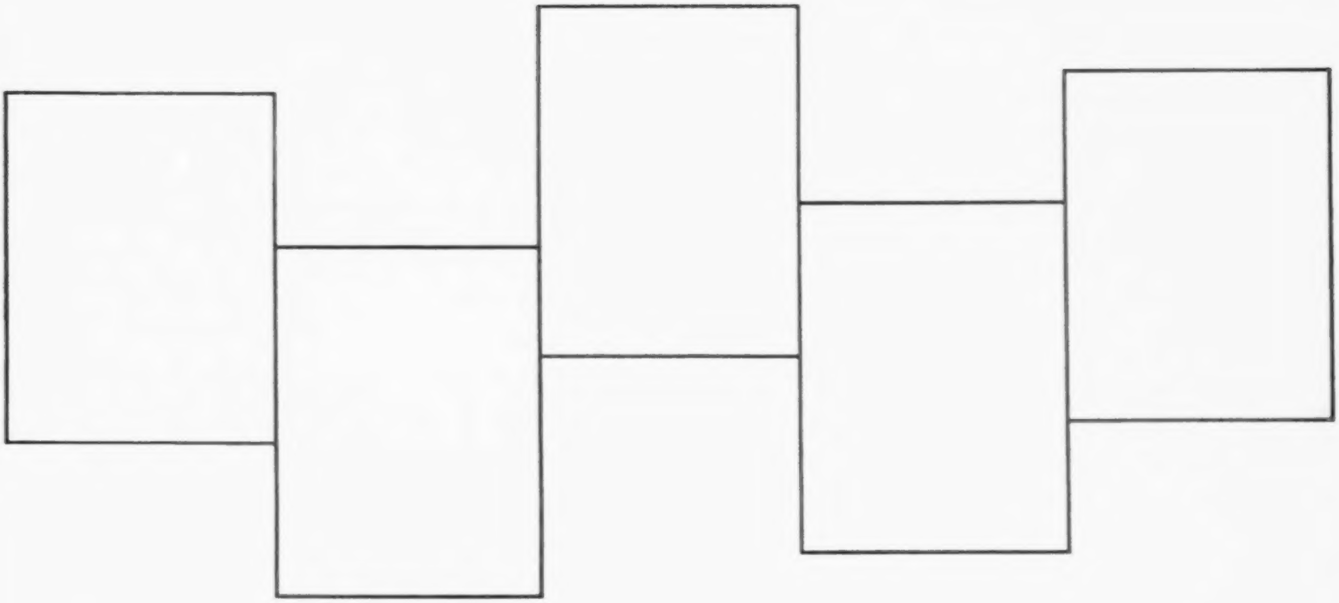
Although some of these topics may be better served under manufacturing it is important to show the interrelations between technologies and the artificial barriers that have been imposed by man. Is not one of the goals of technological literacy to provide an understanding of technological systems and how they relate to each other and to humanity? Given a common data base, design and manufacturing can be more closely linked because of the computer. The same data base that is used to communicate a design can be used to generate the programs to run NC (numerical control) machine tools to finish raw materials, control robots to supply, direct, monitor, and correct the manufacturing and assembly of the product, and order the materials, plan the production, and transport the product.

This powerful tool should be an important part of the communications curriculum. It has the potential to change our understanding of communications as a human endeavor. The computer can change the way we think about communications and how it relates to other technologies. There is the potential to change the very nature of communications. Traditional methods of documenting designs for manufacturing and communications may no longer be necessary. The communications medium for manufacturing will be a stream of electrons. Blueprints will be replaced with bits of data. Designing will change from a paper intensive task to a paper-less and powerful graphic image displayed on a computer screen or an image suspended in space similar to a hologram. Technical illustrations will come directly from the 3-D model produced when the part was designed. The graphic image of the design will be merged with text for technical manuals, advertising, and other printed media. It is conceivable that television commercials will be produced using the same 3-D design model through animation programs.

Summary

Preparing teachers and students for technological literacy in communications is not an easy task. It will take a dedicated professional educator willing to take the extra time and energy necessary to offer a curriculum that will be judged of value to all students regardless of their role in society. Communications is an important element of technological literacy. CADD might seem like a small part of communications but it has the capabilities and the potential to become the unifying element for a better understanding of the communication and manufacturing process.

Implications of Technological Literacy for Vocational Service Areas



Dichotomies, Relationships and the Development of Technological Literacy

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To the best of my knowledge, one of the first individuals in the field of education to use the descriptor "technological literacy" was Dr. Marshall Schmitt, the industrial arts specialist for the United States Office of Education. He was exploring the issue in the early 1960s, over 25 years ago. He was convinced that a technologically literate citizen was essential in a democratic society where an increasing complexity of the technological base had become the norm.

In this paper I continue, with members of this symposium, the exploration of the issue of technological literacy begun by Marshall Schmitt. Concern and interest about technological literacy has grown considerably since Marshall Schmitt's early explorations, some legitimately, some illegitimately, some self serving, some from the concern for the human condition and good for all.

There have been several national conferences, numerous reports on education, a number of articles and several research efforts which addressed technological literacy as a major concern. At this stage, even after some 25 years of increasing concern, there seems to be considerable confusion, yet considerable interest in the topic.

One must question, "Why the confusion?". If the issue is so vital, an educational issue, why can we not derive a structure and an approach that will enable the many components of the education enterprise to move out with the assurance that they know what they are about and get on with it?

Perhaps the problem in that the issue is being viewed from too many narrow provincial perspectives, by the State, by education associations or by corporate interests. Perhaps technological literacy is a multifaceted, mulidimensional construct. At this point in time this seems to be a valid and reasonable conclusion.

Therefore, the focus of my presentation will be to explore some of the dimensions of technological literacy. Perhaps we can identify some of the categories and levels of technological literacy that can serve as a base for discussions about the role and function of formal instructional programs in the development of technological literacy among our citizens. My effort will be to attempt to direct our attention to the more significant issues of technological literacy, the ones truly worthy of professional educators' time and energy and taxpayers' dollars; and the ones that relate to the centrla mission of education in a democracy.

A Growing Concern

The issue of technological literacy of our citizens is a relatively recent but growing concern in our society. An awareness has surfaced that a major problem exists and that something should be done about it. However, as is evident from the literature, the perceptions of the problem are many and varied and there seem to be few generally accepted solutions.

A number of editorials, articles and reports published the last several years have addressed the subject of technological literacy. Among the most prominent reports were by the Commission on Excellence in Education, the Education Committee of the States, The Carnegie Foundation for the Advancement of Teaching and the National Science Board's Coleman Report. The general conclusion of the reports was that *technological literacy needs to be a part of general literacy*. There was also the recognition that technological literacy is different from scientific and mathematical literacy even though in the various sections of the reports the writers were unable to transcent their own biases and often returned to the now thoroughly rejected premise that technological development follows scientific discovery. The reports exposed a general confusion as to what technology is, yet a recognition by some that it is a new and emerging field of scientific study the same as biology, sociology or physiology and other sciences.

Several organizations, including the Council for Understanding Technology in Human Affairs, the

Academies of Science and Engineering, the International Technology Education Association, the American Association for the Advancement of Science and the National Science Foundation, have sponsored meetings on the topic of technological literacy. The Alfred P. Sloan Foundation has awarded $250,000 grants to ten liberal arts colleges for the purpose of developing curricula to increase the technological literacy of liberal arts graduates. Business and industry have been heavily involved also. They are investing some $3 billion yearly to fill what they consider to be an education gap between what people are learning in education institutions and what they need to know to be competent employees.

There is a growing acceptance that it is not only necessary to be trained in certain technical skills but that the study of technology is a necessary component of an educated person, of an informed citizenry; that not only are there skills to be learned in the technologies, as there are skills to be learned that enable one to read another language, but also mastery to be attained that enables one to create and utilize appropriately the technical means. Being educated today implies, more and more, a knowledge and understanding of the creation, use and impacts of technical means. This involves the emerging field of study known as technology. To be an educated civilized person today means attaining a level of literacy about technology similar to our expectations of the attainments of an educated civilized person in art, history, language, literature, mathematics and the other sciences (Haberer, p. 223).

Yet, if each of us was to evaluate ourselves in an objective truthful way we would have to admit a growing ignorance about the field of technology.

The Growth of Ignorance

In a recent column William F. Buckley, Jr. wrote: Second perhaps only to AIDS, there is concern over the growth of ignorance (p. 4A). Buckley cites articles in *Newsweek*, a book by E. D. Hirsch, Jr. called *Cultural Literacy: What Every American Needs to Know*, a column by James J. Kilpatrick on geographical literacy, a proposal by Senator Bill Bradley for a Geography Awareness Week and a program on "60 Minutes." He cites polls that expose the fact that 25 percent of U.S. high school seniors believe that Franklin Delano Roosevelt was president during the Vietnam War and that over two thirds could not place the Civil War within 50 years of when it took place. Twenty-five percent of the college seniors in Dallas, Texas, couldn't name the country south of the Texas border, while 39 percent of the college seniors in Boston, Massachusetts, could not name the six New England states.

Apparently our people are becoming more ignorant, not less, at a time in the civilization process when growth in new knowledge is increasing at almost an exponential rate. James Kilpatrick discovered that, in 1950, 84 percent of high school seniors knew where Manila was. In 1984, only 27 percent of the seniors knew where Manila was (Buckley, p. 4A).

To my knowledge we do not have records of knowledge or literacy about technology by students even in the basic areas such as energy conversion systems, propulsion systems, materials manufacturing processes or technology valuing and assessment. We can only surmise that the results would be similar.

Most thinking citizens would agree that there is a relationship between education and democracy; that a primary component of a democracy is an educated citizenry. And most would agree that to function effectively as responsible citizens in a highly technological democracy, knowledge and understanding of technology is essential. Yet, we face a rather strange dichotomy in our society. At a time when the need for greater knowledge and understanding by our citizens is needed, we find a growing anti-intellectualism among many of our youth and, in some cases, citizens in general. There seems to be a reversion back to simplistic answers and folk knowledge in the search for answers to rather complex questions. There is a growth of ignorance.

One questions why there is this growth in ignorance. Why the lack of interest in learning? When questions are asked of students about their lack of knowledge the general reply is, "Why should I know about some other country"? "Why should I know about the Vietnam War?" Why should I know about energy conversion systems?" "Why wshould I understand about telephonic communication?" With respect to telephonic communications there is an interesting story from Iowa City, Iowa.

Iowa City, Iowa (AP)--At least a few listeners of an Iowa City radio station fell for a real line this week.

They covered up their telephone receivers when Ted Burton Jacobsen, morning deejay on KKRQ-FM, and Steve Sinicropi, sales manager, claimed the phone company was "cleaning out the lines."

Jacobsen ran a fake commercial several times Tuesday saying the phone company planned to "blow soot and dust out of the line" and that people should "bag the phones" to keep dirt from blowing around homes and offices.

Then Jacobsen interviewed Sinicropi, who played the part of "Bill" the telephone company representative.

Sinicropi said the station received a number of calls.

One convenience store reported people were buying plastic bags to cover their phone receivers. Others stopped to call spouses to tell them to take appropriate action.

"Somebody called from one of the malls to say they had covered all the phone receivers there. We even had a call from someone at the University (of Iowa) saying they had bagged the phones," said Sinicropi.

Northwestern Bell officials in Cedar Rapids and Iowa City were not amused. Each had about a dozen inquiries about the sham.

"It was an inconvenience to some customers and unfortunate the station played a trick on some of its listeners," said Bell regional manager Vic Pinckney.

Sinicropi said the station, after a request from Northwestern Bell, ran a disclaimer pointing out the joke. (*Dominion-Post*, July 3, 1986)

How long can we remain a quality civilized society if we have a continual increase in ignorance among our citizens? Ignorance is a cancer for democracy. The condition of ignorance cannot be accepted in a democratic society just because people are satisfied to languish through life as irresponsible self-serving, non-civilized beings.

The potential for the rest of society is too grave given the power of the technical means of today. The choices of the ignorant in the form of collective human action can bring on all forms of disaster. If we are to preserve our democracy there is no choice; well educated responsible citizens are a necessity; and if there are those who are not able to motivate themselves on the basis of their own thoughtful actions to seek an education, then they must accept the directions of other citizens and pursue education or choose to live elsewhere where ignorance is acceptable. The alternative is to abandon the concept of democracy and agree to an authoritarian state. If the growth of cultural and technological ignorance continues the outcome will be a technical elite controlling the ignorant. Why is this so? Simply because knowledge is power and those who understand and control technological knowledge have the power to control others and public policy.

The World of Yesterday

We live in a time in civilization that is truly unique. Vice Admiral James B. Stockdale wrote in *A Vietnam Exerience* as follows:

> The thin veneer of civilization that we know is precious. It is also modern. We could bring together one couple, husband and wife, for each generation of man since he acquired his present appearance and characteristics about 50,000 years ago. There would be only about 2000 couples, and most of them would seem quite odd. The first 1400 of the couples would have lived in caves, and only the last 33 would have ever seen a printed page. (p. 168)

Most of the people in this audience can recite the major changes that have come about in the world through technical inventions, innovations and developments. Those who reflect on changes in their own families will recall that their parents were born into an era where the airplane came of age, where radio and television developed, where new and exotic materials such as rayon, nylon and composites evolved, where the internal combustion engine was improve through new materials, better fuels and turbo charging, where a new form of heat engine evolved from the work of Ellings of Norway, Whittle of England and Von Ohain of Germany, and worldwide communications via satellites, digital electronics and programmable electronic computers.

The World of Today and Tomorrow

Each of us has witnessed major changes in the relation of our country to the rest of the world. We are no longer an isolated nation. We live in an interdependent, ever-changing world, a world of accelerating industrialization, rapid population growth, widespread malnutrition, increasing depletion of nonrenewable sources of minerals and energy, and a deteriorating environment.

Our futures are linked irreversibly to the rest of the world. More and more people of the world are dependent on each other, whether the context is the environment, raw materials, energy supply, finished products, food supply, or knowledge and know-how. The advent of television and communication satellites and the resulting rising expectations of people throughout the world, coupled with the microprocessor and its potential for accelerating the pace of technological change, portend a future far different from the present. Yet, many of our high school graduates are ignorant not only of the technologies on which these worldwide changes are taking place, they are also ignorant of the geography and culture of the rest of the world.

On a local scale we find that many of our neighbors are unemployed and may never return to their former places of work. Those who are employed have discovered that, because of continual inflation and cyclic recessions, they cannot maintain a lifestyle that only a few years ago was considered normal. This is true for millions of well educated middle class people.

We are finding that the United States is no longer competitive in heavy industries, and faces heavy competition from other nations in the development and production of computers, machine tools, construction equipment, automobiles, textiles, electronics and home appliances. Our mounting and continuing trade deficits are manifestations of these events.

In less than eighty years the United States has changed from an agricultural, to an industrial, to what is now called a service economy. Manufacturing, mining, and construction combined account for only 35 percent of the current jobs in the United States. It is predicted by various sources that by 1990 the service sector--banking, insurance, the communication and information industries and fast food restaurants--will provide 80 percent of the jobs. Many jobs in these fields are low in pay, part time, and offer few career advancement opportunities.

The heavy industries--steel, auto, and machine tools--will be replaced in the economy by businesses and industries that facilitate, move, service, and manage, rather than make things. Manufacturing firms have been and are moving their operations to other countries for a variety of reasons including lower wages. The new plants utilize the most sophisticated equipment and management techniques.

The new era we have entered is focused on electronic computing equipment, telecommunications, instrumentation and control devices, the health fields, entertainment equipment and space vehicles and satellites. Some of the new communication firms are already recording market values twice those of the large steel and aluminum producers.

The Information Revolution

During the current decade microprocessors are ushering in a technological revolution that, from all predictions, will have a greater and more profound impact on societies throughout the world than did any other technical event at any other time in history.

All aspects of living are being affected directly or indirectly; education, the home, agriculture, transportation, recreation and health care, to name a few. New uses and applications are being developed every day. Microprocessors provide the means for control of all forms of industrial and business operations providing what has been called *intelligent automation*. Microprocessors are used in oil refineries, chemical plants, paper mills, steel mills, power stations, research laboratories, offices, and homes. They are being used to control internal combustion engines to improve fuel economy and lessen pollution. The range of present and potential applications is staggering.

The design and construction of integrated circuits, the core of microelectronics, have improved so that greater numbers of transistors, resistors, diodes and other electronic components can be placed on a single silicon chip. In 1971, Intel, Inc., following the work of their engineer, M. E. Hoff, brought out the microprocessor by putting the entire central processing unit of a computer on a chip. By 1980, the power and the capability of the microprocessor were increased by new manufacturing capability enabling the placement of 200,000 components on a single chip. The Japanese have chips in development that will contain 250,000 circuits. Currently, manufacturers are working on integrated circuits with one million components and by 1990 they predict as many as 10 million transistors on a single chip.

The microprocessor has brought about the potential of robotics and with robotics there will be a continuing change in the nature and distribution of jobs. It is evident that most people in the world are entering a new world for which they are not very literate or very well prepared.

No technical development in history, including the computer, has had the potential of altering jobs and employment worldwide as has the development of microelectronics and the microprocessor. Not only will jobs be eliminated through intelligent automation, but many jobs will be lost in the manufacturing of electronic products because they contain fewer parts than the products they replace.

The Social Dimension

Another dichotomy and relationship category has to do with social behavior. We live in an interesting era. At a time when the complexity of technical means is increasing and major problems have developed with respect to trade deficits and the growing ignorance of our citizens in most all phases of learning, we find the social behavior of the nation as evidenced by a majority of business leaders to be short-term and bottom line.

Norman Lear spoke about some of the issues as he perceived them in a recent forum of the J.F.K. School of Government at Harvard University broadcast by Public Television (4/17/88). In addition to the short-term and bottom line behavior Lear noted that there seems to be a loss of pride in product and long-term commitment to a business or industry. One business or community seems to be a good as another so long as it turns a profit. The goal is instant success for self, perhaps a natural attitude in a "me" generation and a culture that celebrates commitment to self and instant success.

The problem runs deep in the psych of the nation. In an era where most of a lifetime may be required to master a field of technological endeavor and where the road to even small successes is littered with many failures, we promote values and attitudes that are detrimental to the long-term benefits of society as a whole. We seem to forget that the civilizing process is critical to the commonweal and that this takes times; that learning and mastery of knowledge and know-how and the development of values and attitudes are long term efforts.

Eric Sevareid in a recent interview for *Christian Science Monitor* expressed his concerns about our problems today. He cited three. Each is directly related to the creation and use of technical means. He believes there are three things that are new in history. "One is the leap into space. Another is the existence of ultimate weapons. And the third is the poisoning of the natural sources of life--the rivers, air, food." He goes on to point out that he does not believe that any of our real problems will be solved in outer space. "I think," he said, "they're solved in inner space and inner man and terra firma" (p. 6). The real problems are with our attitudes and values about self, others and our life giving and life sustaining environment. Short of abandoning the Earth we must address our present and future here on Earth.

At issues is freedom and democracy as we know them. The dichotomies and relationships concern:

1. Freedom vs slavery
2. More control vs less control
3. Independence vs dependence
4. More options vs fewer options
5. Freedom and responsibility
6. Freedom and creativity, growth, and advancement

The need in a fully functioning democracy is intelligent well educated and responsible citizens. As the complexity of the society increases socially and technologically there is a corresponding increase in the requirements for basic literacy in social and technological realms.

The technological society is a knowledge society; a society that today requires a new form of literacy if all citizens are to function effectively as free and responsible members of the society. To participate effectively in a democratic society it is critical that *all* members understand the multiple relations among various technical systems and human affairs. Many of the decisions that have been made individually and collectively, by highly educated scientists, industrialists and businessmen, as well as collective decisions by average citizens, have, in many cases, been highly detrimental to the long-term enhancement of the quality of life and the sustainability of the technological and ecological systems on which human civilized life depends.

Thomas Jefferson recognized the *need* for intelligent citizens for the proper functioning of a democratic society.

> I know no safe depository of the ultimate powers of the society but the people themselves; and if we think them not enlightened enough to exercise their control with a wholesome discretion, the remedy is not to take it from them, but to inform their discretion by education.

A New Form of Literacy

The basic premise of Thomas Jefferson holds as true today as when he wrote it. But things have changed. We are discovering that technological systems designed and developed by a mentality of another era are not sustainable. The problems and issues facing citizens today concern the search for alternatives to present technical systems, either by the design of new technical means or by the redesign of present ones. Successful designs will require new knowledge and understanding of the *behavior of systems and the relation of the various elements and components of a system to the total.* Today, technical systems function on a global basis and decisions made by businesses, industries, and governments elsewhere affect directly the businesses, industries and people in our own community.

To gain control of our futures will require, especially in a democratic society, a new form of literacy by all citizens if appropriate decisions are to be made and implemented. The basic question becomes: "What learning is of most worth with respect to the design and control of technical means at the community level by citizens? At the regional or national level?" Simply answered, it is *the knowledge and know-how that has to do with the behavior and control of technological systems in relation to human affairs and social purpose.*

What should all citizens *know about* technical means? What should they *be able to do*? Obviously, every citizen cannot know all there is to know about all of technology and human affairs. Therefore, the search must be for the structure of the discipline; the central themes, systems, concepts, and principles that *provide insight into the behavior of technical means,* not only technically but in relation to, and within, social-cultural and environmental contexts. The goal is control of technical means by technologically literate human beings. This means to attain control is to gain knowledge and understanding of the behavior of socio-technical systems and their relation to human beings and their environment.

True literacy will require sustained effort over time to develop knowledge and understanding of the abstract concepts upon which the technical world has been created and functions. This level of understanding cannot be gained from hearing or reading about inventions and technical systems. What is required is direct and sustained involvement in the processes of the technologist. The mind must be prepared to be capable of observing and establishing differences, similarities and relationships. Human beings are not only perceptual beings, they are also conceptual. They are capable of learning and using technological modes of thought; the intellectual processes or methods of inquiry used by technologists.

A significant part of the literacy issue is language. Language is not just a means of communicating thoughts, ideas, concepts or technical information; it also structures the way people perceive themselves and how they act and function. Being technologically literate requires that the individual be conversant in several technical languages, including the symbolic languages of the various technological systems.

Technological systems are composed of elements that are related and which interact in some way. Everything exists in relation to other elements within an immediate and total environment. This means that there is some context within which an element, particle, person, tool, event, action or some other part of a system, acts and is acted upon. Perceiving the dynamics of a system requires first the identification of some central theme, function or behavior, whether the concern is with the composition and behavior of a given material, a component of an electronic communication system or the relation of technical devices to social or environmental change. *The goal is understanding and predicting the behavior* of technical means.

What has been occurring is the evolution of a new discipline, a new form of literacy, which is not dependent upon or subservient to science, as commonly known and perceived, but is a new science, the science of technology. The intellectual endeavors involved in the creation of the technical means of today are of a different order from those of the craft era of the past. The new modes of thinking have established the base for the new discipline and the new science. Those involved in this new science are concerned with the *behavior* of tools, machines and technical systems in relation to human beings, their societies and the environment. Technologists base their work on information about the behavior of multiple variables and dynamic environments. *The goals are predictability, replication, reliability, optimization and efficiency of system operations based on objective knowledge.* Emphasis is on logical, instrumental, orderly and disciplined approaches. The view is supported by most recent investigations that conclude that technology and science, as commonly perceived, are distinctly different forms of human behavior. The concept of technology and science being different ends of the same continuum is probably false. What is probably true is that technology is one of the sciences as is biology, psychology, anthropology, sociology and other disciplines concerned with human behavior, and the term science, as commonly used, is the source of the problem. Even if the problem is explored using the commonly accepted definitions of science and technology, we find two distinctly different forms of activity with different goals, questions, and means. Each field is mutually exclusive and not mutually dependent, although as with all sciences, each has been enhanced by the other.

Technology Education

The design of an education system to develop a level of technological literacy in all citizens is a complex task. It is, however, a critical and necessary task for a democratic society.

The belief that human beings attain their highest level of human attainment in a *free society* and that *participatory democracy* is the best form of government presupposes that citizens must participate in decisions concerning the design, development, and use of technical systems. *Participatory democracy* in a society with more than a primitive order of technical means requires *participatory technology*. One without the other will not work.

Participation in social or technical decisions requires social and technical knowledge and access to social and technical tools.

These are the preconditions if citizens are to again become part of the process with a sense of intelligent participation and not alienation. The challenge to education brought about by the random development of technical means demands major alterations for one primary reason. The characteristics of a society based on a high order of technical means alter the questions with respect to error and failure. Failure in a complex, modern society is of far greater consequence than in earlier societies.

In earlier times are technical means was not as powerful, dependency on multiple subsystems not as great. If systems were disturbed they returned to equilibrium in a relatively short period of time and damage to human beings and the environment was limited. Not so with respect to the technical systems of the twentieth century. Yet, as dependent as the survival of society is on the efficient functioning of highly complex technical systems, we find that today the great masses of people are denied access to the tools. The tools of our technical systems have become the property of experts and are under the control of specialists. Thus, the control of the evolution of technical means and society becomes the province of select specialists, none of whom have the responsibility or mandate to be concerned about human affairs, social purpose and total systems.

If citizens are to regain their freedom and obtain control of their destinies, then they must become involved in the study of technology and gain access to the tools.* (*Tools in the sense used in this seciton refers to all devices from the most simple to the highly complex which are used by society to produce goods and services; transmit, store or retrieve information; and transport goods and services; together with the know-how of their use.) Dependency on common sense and the folk knowledge of yesterday will not suffice. The technical means of today, with its sophisticated tools and knowledge, requires disciplined and systematic study, from a technical standpoint as well as a social-cultural perspective.

Most citizens have never had the opportunity for the disciplined and systematic study of these systems. Even the technical experts are limited in their understanding. The generally know about and understand the physical forces and principles which provide stereophonic sound, linear induction motors and color photography. Those who create these devices know about and can control these devices. But the issue is not the control of a single device; *the issue is the understanding and control of the behavior of technological systems as a major component of social systems and as a critical factor in cultural change and disruption within societies.*

The education of citizens for participation in decisions about and the management of society for human purposes concerns not only the study and comprehension of the behavior of the various technological systems and the technical elements and the tools associated with these systems, but also the behavior of total systems including the relationships to human beings, the social/cultural components of the environment and the total system. The concern would be with the dynamics of the system. The focus would be on what each element *does* within the system, not what a thing *is*. The goal of education would be to provide citizens with a means to gain knowledge, to gain control, and thereby mastery over the tools to serve human purposes.

Unfortunately, education efforts with respect to the study of technology have been narrowly directed, for the most part, toward the preparation of individuals for jobs and specialized role in society rather than the preparation of self-governing citizens. Also, it has become evident that the new and expanding knowledge base of technology has transcended most educators, and the competence of the average citizen. Many educators have treated the study of technology as something apart from the daily affairs of citizens and the responsibility of public education. By doing so they have effectively turned over the control of a powerful tool to a regime of experts and denied their students access to the very knowledge and tools so vital to the processes of creating, managing, regulating, and directing technical means for human purposes. Educators often view technology as an "object" and not as a "subject," as something "out there" not really important to education for life and living and thus inappropriate for study. The technical means of society seems to be an abstract created by some individuals which exists outside the sphere of awareness of educators.

Because of this the education system has muted the awareness of citizens of their ignorance of technology and pursued the policy of machine tooling citizens into marketable commodities in narrow specialities.

The education system creates what Arthur Koestler calls an "urban barbarian" by denying students access to knowledge and tools and limiting their interest in and awareness about technology. Citizens are placed in the position of being effectively shaped and controlled by those in command of the tools and knowledge of the new technologies. Also, the comprehension of the behavior of total systems is voided and technology becomes less and less responsive to citizens and human purposes.

The issue seems to be one for which education, as a social institution, has not developed successful alternatives. Most education programs have focused on the past, the here and now, and on meeting rather specific vocational needs. What is required is a new mentality, a different way of perceiving society and technology. All citizens should be involved in determining the questions and finding the answers, and they should be prepared for participation in the process with adequate knowledge and tools for the task. This means a comprehension and understanding of the *concept of system* and the understanding of the interrelatedness of systems and the elements of a system. Everything affects everything else.

The goal of education should be to provide individuals with the means to find order in a complex global society and to attain the knowledge, skills, tools, attitudes, and values required to participate fully in determining the nature and direction of their society and in the management and operation of their society.

The issue of technology education and technological literacy impacts on all levels and categories of society. Technologically literate citizens would not only enhance and protect our democratic way of life at all levels by being capable of participating in the decision making and management of their society, but they would also be better able to contribute in significant ways to the needs of business and industry in a highly competitive global economy where change is inevitable and continual learning and relarning is required. The new literacy, technological literacy, can enhance our competitive potential.

The technologically literate citizens would also be more self-reliant and capable of meeting their own needs and those of their communities, thus enhancing the quality of life at the local level. The new literacy focuses on the *role of the individual in a free society* who functions in many roles and is ultimately responsible in democratic societies for the proper functioning of their communities and nations.

It is also important to remember in the age of high technology that technologically literate citizens are better able to serve the needs of their nation in times of national emergency, political or otherwise.

Without access to tools and knowledge of technological systems, citizens effectively lose control of their technology. They have become totally dependent on technical means, yet ignorant about them. To alter this course will require that *technology becomes a basic component in the education of all citizens so they are conversant in the language of technological systems and can comprehend the basic concepts, the dynamics, and the interrelatedness and impact of technological systems at all levels of society.*

The Human Dimension

The human factor in society presents us with many problems because of the great variabilities that exist. These variabilities bring to the field of education many problems which pose serious obstacles to any effort addressing complex issues such as technological literacy. As one explores the issue, it becomes obvious that in addition to the dichotomies and relationships already explored, there are also dichotomies and relationships related to human traits and behavior.

Some 17 years ago, I had the pleasure of organizing, with Wil J. Smith, a conference at West Virginia University on the theme, "Education in a Technological Society."

It was a two-day conference and during this time we explored topics such as Technology and Social Purpose, The Future of Man in a Technological Society, Technology and Change: Educational Imperatives, and Education, Technology and Human Values.

One paper was delivered by Walter Lowen who at that time was Dean, School of Advanced Technology, State University of New York, Binghamton (pp. 34-35).

Walter Lowen made three points in his presentation which impressed me. One, he said he was very optimistic about the role of technology in society. He believed we should not become enslaved by technology; rather, technology should make us free and therefore add to the dignity of man and give us more of an opportunity to be human, not less. Second, he addressed the reason why many people are negative or less hopeful about technology. He stated that the primary reason is that there is confusion about what technology really is. He noted that technology is not the products produced or the things such as light bulbs, automobiles, jet engines or nuclear reactors. Rather, he stated: "It is a way of thinking, a series of methodologies that have evolved for solving problems." Lowen noted that certain words have entered our language as concepts that enable us to "think about" and solve technical problems. These include feedback, critical mass, network, parametric systems, programming, algorithms and operational modeling, to name a few.

The importance of the second point made by Lowen at that time has, I believe, been overlooked by educators. For the most part educators consider technology to be things and thus focus the curricula on teaching about things, thus missing the potential to develop the field of study so that students gain insight into the discipline and are able to reduce the confusion that exists about technology in society.

The third and very significant point that Lowen reminded us about in the fall of 1970 was that people are different; that there is a whole spectrum of human traits or behaviorally built-in characteristics. In his presentation Lowen developed a model which he referred to as a map of human characteristics.

The model is shown in Figure 1. You will note that in the model there are two axes. The *vertical axis* has one pole which focuses on *people* and verbal sensory inputs, while the other pole focuses on *things* and graphical sensory inputs. The horizontal axis dichotomizes the *concrete* and *abstract* and identifies people who are characterized by the way they relate to their world, some in a *coordinated* way and others in a symbolic manner.

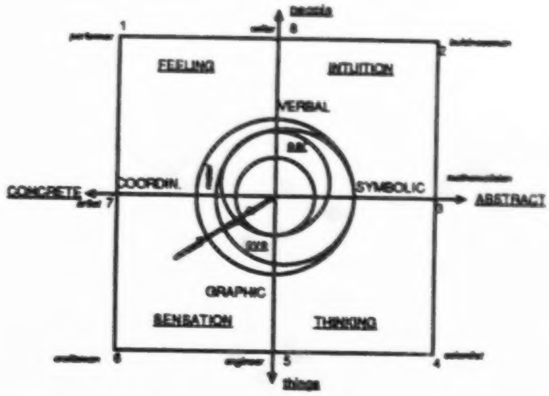

Figure 1. Class.ication of human traits. (Lowen, 1970, p. 39)

Lowen further analyzed personality types following Carl Jung's work. Jung postulated there were introverts and extroverts and later proposed that there were people who could be classified as *feeling* types, *intuitive* types, *thinking* types, and *sensation* types. Lowen superimposed these characteristics on his dichotomous diagram as is shown in Figure 2. In his analysis Lowen noted that peole can be combinations of adjacent fields by rarely combinations of cross fields. Thinking and feeling are opposite poles as are intuition and sensation.

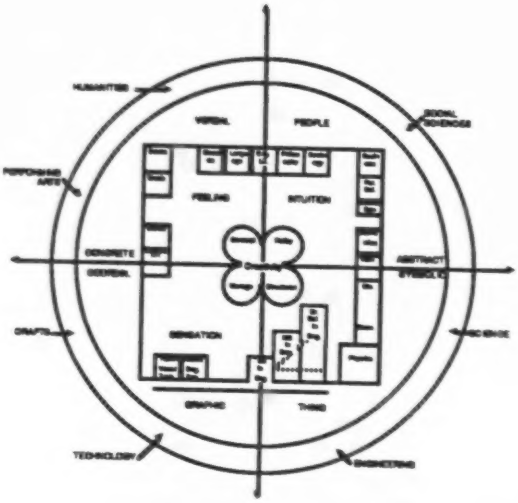

Figure 2. Human traits in relation to curricular offerings. (Lowen, 1970, p. 41)

The importance of Lowen's work is that it illustrates the difference in people. His work has importance for those in education as they consider curriculum development or abstract concepts such as technological literacy. If we relate various types of human endeavors to the various segments of Figure 2 we have an interesting and informative model which enables us to observe the spectrum of human traits and their related human endeavors.

Notice that schooling, for the most part, has dichotomized the curriculum into similar compartments. The goal is to produce highly compartmentalized, focused, polarized individuals who function appropriately as biologists, sociologists, mathematicans.

The problem is that the problems of today are systems problems. There are no one-discipline problems. Our problems today have to do with urban and rural housing, toxic waste, energy conversion, unemployment, health care, international competition, privacy, transportation and education, among others. The appropriate solution to our problems rests with people who are able to bring the opposite poles together toward the center where they can be creative and where the thinking concerns concepts, policy, structure and management.

In 1982 Walter Lowen authored a major work titled *A Systems Science Model of the Mind and Personality--Dichotomies of the Mind.* In this work he developed a 16-pole model, expanding on his earlier work. Figure 3 illustrates this model. The original dichotomies exist, abstract-concrete and people-things, together with the identification of the "capacity traits" related to mouth output, mind output, hands output and body output that relate to words, tone, data, and facts. Lowen calls this diagram a "map of capacities." Each individual is different. It can be posited that this diversity of traits and capacities were the prime factors in the creation of our complex, pluralistic society of today.

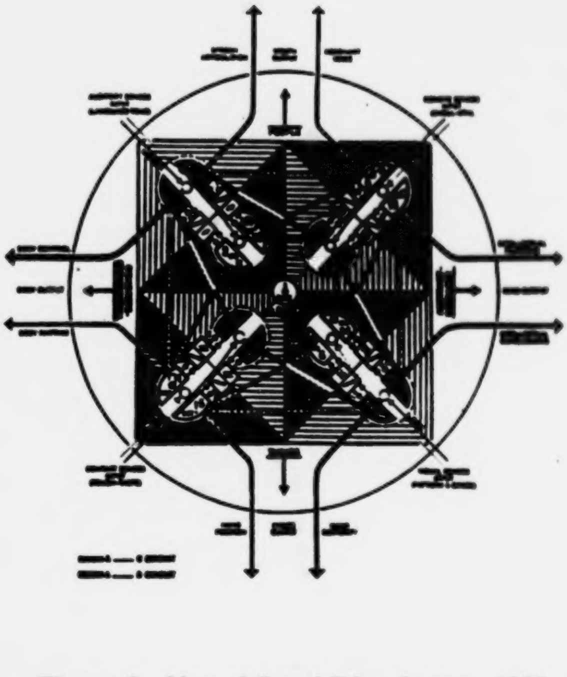

Figure 3. Map of Capabilities (Lowen, 1982, p. 100).

Lowen in his study provides examples of various human profiles that relate to certain work activities (see Table 1). The profiles are categorized by the four poles--intellect/abstract, verbal/people, hands/things and body/concrete.

The two poles that have traits associated with the field of technology are intellect/abstract and hands/things. Within these modes as Lowen identifies them are profiles which are identified by terms such as analyst, conceptualizer, suspector, and theoretician for the intellect/abstract mode and implementor, organizer, operator and molder for the hands/things mode.

Concepts, Consequences and Technological Literacy

The dichotomies and relationships that have direct impact on the question of technological literacy range from the growth of ignorance in an era of increasing technological complexity, to the lessening commitment to learning and an increased concern for short-term monetary gains in a society that requires more intellect commitment, not less, more knowledge, not less and longer-term commitments

Examples of Profiles and Work Activities

Mode	Profile Name	Work Activity Examples
Intellect Abstract [illegible]	Analyst	Science and applied science, Applied math and physics, systems analysis, engineering science, law, medicine as diagnosis, trouble shooting (anything involving logic with verbal skill)
	Conceptualizer	Architecture, corporate planning, systems design, conceptual research, management of innovation (anything involving logical structures with visual skill)
	Suspector	Detective service, pure mathematics, military or strategic planning, comptroller (anything involving strategies and planning with visual pattern recognition skill)
	Theoretician	Theoretical physics, intuition-driven research
Verbal People [illegible]	Verbalizer	Orator, preacher, diplomat, actor or director, writer, english professor
	Critic	Critic, voice teacher, foreign language teacher, translator (anything involving attentive hearing skill)
	Perceiver	Counselor, clergyman, social worker, [illegible], family law, psychiatrist
	Composer	Poet, lyricist, composer, writer, psychiatrist, artist
Hands Things [illegible]	Implementor	Engineer, experimental scientist, project manager, contractor
	Organizer	Secretary, salesperson, stock clerk, accountant, dietitian, office clerk, programmer, administrator
	Operator	Machinist, surgeon, manager, auto mechanic
	Molder	Sculptor
Body Concrete [illegible]	Classifier	Politician, administrator, athlete, anthropologist
	Follower	Nurse, musician
	Initiator	Entrepreneur, salesperson, opportunist
	Doer	Dancer, athlete

Table 1. Examples of Profiles and Work Activities (Lowen, 1982, p.231).

to mastery of the complexities of an interdependent increasingly technological world. It is difficult to determine how best to approach the question of technological literacy in a democratic society especially when we recognize the great diversity of human beings. Are there any constants? Are there any central themes that educators can use to aid in addressing the problem? Certainly it would be impossible to require all citizens to become experts in all phases of knowing and doing in music, art, literature, biology, psychology, technology and other fields of human endeavor. How, then, can the problem be addressed? Where shall we direct our efforts?

I suggest that any valid approach must emerge from one's world view. What are your assumptions about life and living, about people, resources, life on Earth and the purpose of life? Who are we? Why are we here? Where are we going? Answers to these questions, which are as old as civilization, provide the base to determine "how are we going to get there?"

Various approaches to the question of technological literacy have been proposed. Some are narrow or instrumental and focus on corporate needs, national defense and job preparation. These approaches serve the operational needs of society. Other approaches focus on the larger cultural and democratic dimensions of technological literacy (Haberer, p. 225).

Given the problems of the growth of ignorance and the social behaviors of short-term goals, instant success and the bottom line, and the ever limited resources of public education, it seems best that attention be directed to basic literacy first, together with emphasis on human goals and social purpose. If one does not have the basic tools for learning and has not determined answers to the question of where and why they are tending, it is of little use to attempt to address the complex question of technological literacy.

Secondly, it seems imperative that the equation of technological choice and social and environmental consequences be addressed. Rather than accept as a given the continual infusion of technical means into society, the equation must be reordered. The primary equation should be the design and selection of technical means for an agreed-upon social purpose. This approach then provides a base to address technological literacy for all citizens. This approach focuses on knowledge about and assessment of technical means in a context that provides for intelligent choices.

The preparation of intelligent responsible citizens for life in a complex interdependent changing world then rests on the identification of those constants relating to knowing and doing in the technologies required of all citizens. This assumption follows Netzer's Rule of Irretrievable Loss which says:

> Students should be taught on a compulsory or universal basis, only those things that large proportions of them will never learn unless exposed to the material at the stage in the education process in question, and which it is important that most people passing through that stage do learn.

There are many ways of approaching the question of "what should be universal and compulsory in the study of technology studies?" There are many ways to answer the question. An economist would focus on the production function, an engineer on the technical, an anthropologist on the cultural and a sociologist on the social. None of these single discipline external views of technology is sufficient to structure a program of technological literacy today. What is needed is a focus which has been evolving from the new and emerging science of technology, namely, "the study of the *creation and use of technical means**--tools, machines, techniques, technical systems--and the *behavior of technological systems* in relation to people, their societies, the environment and the civilization process." (* Technical means is used by the author rather than technology. Technology is the discipline or field of study (-ology); technical means are the elements created and used which are the object of study.) A technological literacy focused on the *creation, use, behavior* and *relational factors* of technical means provides a base upon which to develop programs of study for the preparation of intelligent and capable citizens of a democratic society.

To place the foregoing definition in focus and to provide a perspective from other standard forms of literacy, the question can be asked: "What does it mean to be literate in French or Russian?" A typical reply would be that the student should be able to speak, read and write in the French or Russian language, implying a knowledge and ability to perform using the language. It also implies a knowledge and understanding of the history and culture of the countries where the language is primary. Similar criteria would apply with respect to technological literacy.

The definition of technology provides clues to the learning activities that would be meaningful, cumulative, and have long-term applications. For instance, studies concerning the *creation and evolution* of technical means and systems would provide insight into the *relation* of these means and systems to human beings and society, thus establishing data for the derivation of *concepts* and *principles* concerning their *behavior* on which assessments and predictions could be based.

Understanding how technical means are created would aid in improving our ability to design and create *appropriate technical means* for our communities. Citizens knowledgeable about the use of technical means and systems would have better *insight* into the best or most appropriate procedures as well as problems associated with the adoption and use of technical means by society. The latter knowledge could then be used in the design of alternatives to our present problem-plagued technological systems or for the redesign of current systems to attain a greater degree of compatibility with human beings, their communities, and the environment.

An example of the relation of technical means to human beings and society is provided in Figure 4. Here we observe that changes in sanitation facilities, brought about by changes in population, are related to increases or decreases in disease carrying bacteria.

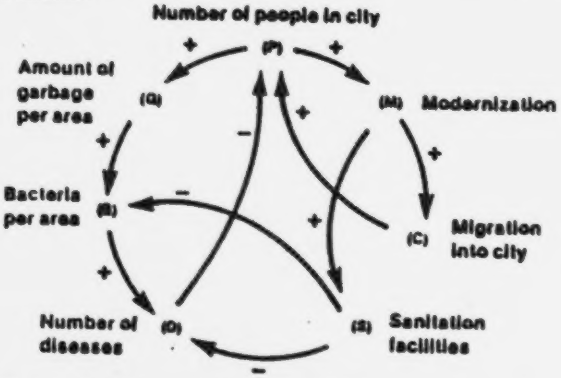

Figure 4. (Maruyama, 1966, p.58)

Knowledge of the technical aspects of systems would focus on the *behavior* of material transformation processes. However, the operational behavior of systems and subsystems would focus on *techno-social relationships*, perhaps one of the more *complex* categories of learning. The techno-social relationships would concern the relation of technical means and systems to individuals, communities, work and employment, and the natural environment. Here, the focus of learning would be on the identification and use of concepts and principles for assessing and predicting the effects of the introduction of a new technical means into a social and natural context. Involved would be the processes of technological assessment and the prediction of probable impacts and risks.

Emerging from an analysis of the definition is the realization that there are four basic interrelated systems that determine the structure and ethos of any society. There are: the ideological, sociological, technological and ecological systems shown in Figure 5.

The diagram in Figure 5 provides a structure which illustrates the major systems and their relationships. In addition to a system relational diagram there is a need for a structure which illustrates the *dynamics* of the processes of the system. The participatory processes in which people are involved as they pursue the design of technological systems to serve social purposes are shown in Figure 6. The first diagram answers questions about systems and relationships while the second diagram illustrates the dynamics of the content by showing the relationships among the systems--ideological, sociological, and technological--and the human intellectual processes involved in the evolution of the ideological, sociological, technological, and ecological systems and society. Three critical processes are involved--valuing, enabling, and assessing.

Other categories implied by this focus would be studies about evolving and future technical means and public policy concerning the adoption and use of new technologies. Included in the latter would be studies concerning employee adaptability to technological change and the appropriateness of given technical means and systems with respect to quality of life and sustainability of communities.

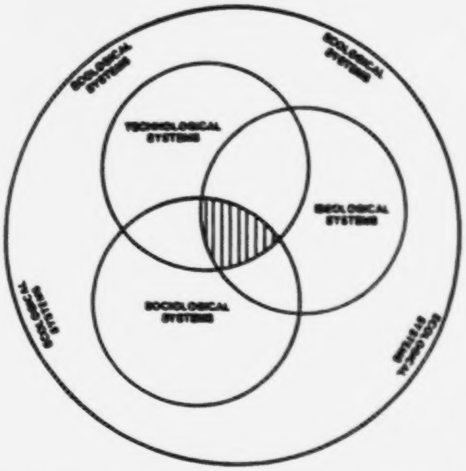

Figure 5. The Interrelationship of a System (DeVore, 1980, p.339).

The structure illustrated provides the means to identify content for curricula for the study of technology and the measurement of outcomes to determine technological literacy.

Ralph Slaght cautions us to not confuse courses *in* technology, where a technical system itself is taught and mastered, with courses *about* "technology," where a technical system is examined and evaluated but seldom learned. Slaght stresses the need to know and be able to use the intellectual processes of the technologist by having direct experiences in the technologies (p. 30). Slaght's position is valid. Just as it is not possible to be literate in another language without being able to read, speak and write the language so too is it impossible to be technologically literate without becoming involved with technical knowledge and technical systems and their elements and operations.

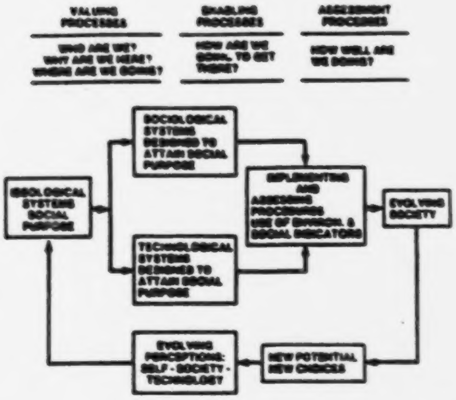
VALUING PROCESSES
WHO ARE WE?
WHY ARE WE HERE?
WHERE ARE WE GOING?
ENABLING PROCESSES
HOW ARE WE GOING TO GET THERE?
ASSESSMENT PROCEDURES
HOW WELL ARE WE DOING?
SOCIOLOGICAL SYSTEMS DESIGNED TO ATTAIN SOCIAL PURPOSE
IDEOLOGICAL SYSTEMS SOCIAL PURPOSE
IMPLEMENTING AND ASSESSING PROCEDURES USE OF EMPIRICAL & SOCIAL INDICATORS
EVOLVING SOCIETY
TECHNOLOGICAL SYSTEMS DESIGNED TO ATTAIN SOCIAL PURPOSE
EVOLVING PERCEPTIONS: SELF - SOCIETY - TECHNOLOGY
NEW POTENTIAL NEW CHOICES

Figure 6. The Evolution and Relationship of Technological Systems (DeVore, 1980, p.340).

The same is true for those who would propose programs for attaining technological literacy that do not involve the relation of technical systems with human beings, social knowledge and social systems. Such approaches will be abortive and interfere with the development of the kinds of programs required to attain true technological literacy, a critical and necessary component of today's education if the goal is to return the control of technical means to people to serve human purposes.

Given the multiple dichotomies and complex relationships, those who have accepted the mantle of leadership in education have a monumental challenge. It is: Design and implement a curriculum and system of instruction in the field of technology that will meet the needs of all students as part of their basic education as citizens in a democratic society. This is the basic challenge, the rest is commentary.

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Technology's Impact on Education: Don't Leave It to Chance

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Two truths have emerged regarding the age of technology. First, technological development will continue to expand at its apparent exponential rate. Second, the transfer of technology will continue to proceed from the laboratory through prototypes and sophisticated application to widely used consumer products. While we can forecast these technology trends with reasonable confidence, we cannot predict accurately incremental changes and specific applications.

For educators concerned with the relevance of curriculum and the timely infusion of advanced technologies into programs, this systematic planning of educational change is a monumental task. Not only are curriculum experts seldom included in the technological development processes they do not possess sound systematic models for analyzing the impact of technology on the nation's labor force.

Their choices are few in number. Curriculum experts can pilgrimage to the mecca of the futurist. Careful study of futurist predictions will lead to the development of worthy concept pieces, but seldom does this fountain of knowledge lead to concrete programmatic changes. The information is essential but not sufficient. Or, the curriculum experts can conduct occupational survey and document specific knowledge and skills. But this process assumes major adaptations of the technology into common practice. In this case the information is sufficient but not timely. In sum, these in exact methods do not offer sound guidelines for determining what knowledge and skills are appropriate for the educational system and at what level. What has been lacking is an organizational strategy which would enable educators to anticipate technological change which in turn will affect programs. In-depth, sustained, and collaborative efforts are needed.

By way of example, let me recount an event in 1964. (1) A teacher education class at a midwestern university included (a) the observation of an injection molding machine and (b) a field trip to an on-line polymer raw material producer. Both activities were fascinating experiences though they provided limited structured information. However, the course was really about fabricating materials, so all other learning experiences were in woods and metals. After all, that was the knowledge industrial education teachers needed in 1964, or was it?

Twenty-three years later, there is more volume of polymers than metals produced in the United States. (2) And, in Indiana, the polymer industry is one of a few which shows growth. Yet, what does the curriculum of the state's industrial education programs emphasize? You guessed it, we are heavy into metal. In retrospect, what should the teacher education program have taught?

Perhaps this isn't a serious problem. No second chances on this question. Indiana and many other states are losing jobs rapidly in the steel producing and metal fabricating industries. Little wonder the midwest is unkindly referred to as the rustbelt.

Well, the purpose of this paper is not to kick the shins of conscientious educators who want desperately to offer the soundest educational programs and wo struggle constantly with the difficult task of changing school curricula. The purpose of this paper is to describe one approach which has successfully brought together educators, scientists, engineers, and managers to consider the pervasive impact of advanced technology.

The Corporation for Science and Technology

The Corporation for Science and Technology (CST) was established by legistlative enactment in 1982. It was created in part, to undergrid the state's economic development effort. First, state leaders knew many jobs would be lost to changing technology through the relocation of major employers and the production efficiency realized through advanced technology. Second, the state had to refocus its industrial base; however, it was realistic for Indiana to remain product production oriented. To achieve this objective required focused efforts in specialized advanced technologies. Government and private sector representatives collaborated on the identification of the most promising technological fields. The effort culminated in the CST's working agenda.

Wisely, legislators did not set their new corporation creation adrift in the uncharted seas of technology with a ten year budget of 150 million. From the beginning, a powerful tri-representative governing board was created. This board was composed of major government leaders (e.g. the lieutenant governor), educational officials (e.g. university president), and economic sector representatives (e.g. CEO of Magnavox Government & Industrial Electronics Company). See Figure 1.

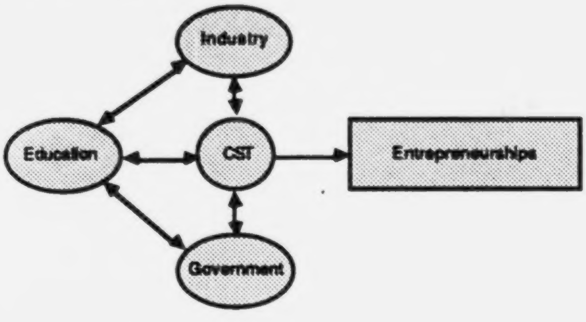

Figure 1. Partners in the CST Organization

Among the members of the 25 person board are three individuals readily identified with vocational education including the State Director of Vocational Education and two college presidents. The board manages the Corporation, a non-profit entity, and assures its consistency with the legislative mandate, the needs of the state, and the emerging technologies.

The purpose of CST is to strengthen the long term industrial base of the state by infusing advanced technology into new business start-ups and new product lines within businesses (Campbell & Hague, 1986). Thus, CST is a planned response to the forecasted dramatic change in the economic sector. Over the next two decades the state's factories, offices, hospitals, medical offices, libraries, stores, schools, transportation systems, communication systems, and homes will change significantly because of scientific breakthroughs and applications of advanced technology. Consumer demands for (a) lower unit costs and (b) increased quality of products and services will continue to be a driving force.

Through the partnership with government, educational institutions, and the private economic sector, CST has the capacity to promote application of new technologies to products and services, engineering and design systems, design and test simulations, manufacturing and quality control programs, office operations, sales and marketing programs, training activities, and accounting and management operations. Thirty-one million dollars have been invested to date in a number of projects. The projects are of three types: (a) start-up and initial support of seven research centers, (b) research and initial engineering phases of a number of advanced technology new product lines, and (c) start-up of new advanced technology businesses.

The investment of the public funds is a means of leveraging private funds which have been matched on an average of 11 to one. Grants for new products have a pay back provision which provides for a portion of the products' revenues to be returned to the Corporation for reinvestment. Clearly, a major dimension of the Corporation is its investment in promising projects which are consistent with targeted technologies.

Working Structure of the Corporation

The small professional staff of the Corporation is primarily concerned with daily operation, proposal development, and contract administration. However, the backbone of the organization is its technology committees.

There are 13 technology committees and two educational committees (see Table 1). As noted earlier, Indiana has identified special advanced technologies for development. State leaders felt these technologies were consistent with the human and capital resources of the state and offered the greatest competitive advantage for economic development.

In general, the committees' mission is to "identify the technological threats and opportunities" which will impact Indiana's future and to maximize the state's public and private abilities to seize economic opportunities. In short, these business, academic, and government leaders are creating the state's foundation for economic expansion and applications of advanced technology. The technology committees are composed of some of our state's finest minds in research and engineering. They come from universities, government, and the private sector. Over 500 members contribute their insights, monitor technological development, plan communication activities, provide technical consultation, and recommend funding priorities and projects.

Table 1

Technology Interests of CST Committees

Committee	Interests
Advanced Materials	Powdered metallurgy: super plastics and adhesives; polymer, ceramic & metal based composites; superconductive materials; structural ceramics
Agricultural Genetics	Genetic manipulations, embryo transplants, plant genetic modifications, All applications to agricultura operations
Artificial Intelligence	Expert systems, computer architecture, natural language driven processing, vision for robotics, optical scanners of written text
Biotechnology	DNA probes, monoclonal antibodies and enzymes, medical diagnosis, waste management, biotechnic quality control
Control Systems	Computers, microelectronics, optical systems, sensor systems, iterative feedback process control systems
Energy Development	Combustion technologies, post combustion treatments, shale oil, cogeneration systems, solar voltaic systems
Industrial Byproducts	Elimination of waste, usable products, regulation of hazardous and solid waste
Information	Computing power, interface processing standardization, simultaneous voice and data handling
Integrated Optics	Optical sensors, optical metrology, optical signal processing, fiber optics, nonlinear optics semiconductor electro-optic devices
Manufacturing	Automated process controls, integrated design, interfere standards, 3-D vision, color and pattern recognition
Medical	Out patient treatment in home based systems, less invasive surgery, implanted microelectronic circuits for muscle and function control
Microelectronics	Higher density, speed, and reliability chips, broader applications in medium and small industries
Telecommunications	Integrated digital networksystems; optical applications; extensive applications in homes, medical care, business and industry

This information on committee interests was drawn from a presentation of CTS President John Hague (1987) and the CST Annual Report (Campbell & Hague, 1986).

During the current year, each committee developed long range plans which synthesized its operational approach with the knowledge of the threats and opportunities it envisioned for the state. Additionally, a new plan piloted which brought selected committees together to study anticipated changes in institutions and the implications these changes might stimulate in the technologies. Thus, a kind of matrix analysis of these changing institutions was developed.

Unquestionably, homes, hospitals, schools, farms, and factories will change dramatically in the next two decades. These changes will no doubt respond to advanced technologies in many of the identified areas and a change in one technology quite possibly will prompt major developments in another. For example, medical practice will likely include diagnosis aided by application of expert systems, the so-called artificial intelligence, perhaps followed by surgery using laser beam technology. What will these changes require in workstation design, advanced materials, and power sources? To consider such questions, experts from the five committees would interact. The creative potential of this cross team effort shows great promise.

The committees, through members' expertise, are the link between the frontiers of advanced technology and applications in the economic sector. They provide a window through which one can view the likely impact of technology on the workplace and the implied impact on those workers whose skills will be most affected by these changes.

Vocational Training Committee

The Vocational Training Committee and the Science Education Committee are the two education oriented committees. While each has its own mission, their common missions are (a) to consider the impact of advanced technology on the needs of the state's citizens and (b) to develop recommendations and informational programs for the education and training enterprise.

The specific mission of the Vocational Training Committee (VTC) is to moniter developments, trends, needs, and opportunities resulting from advanced technology to which employment education and training systems must respond if the state's human capital is to complement the economic opportunities.

This Committee was established in 1984 under the very able leadership of Ms. Geneva Fletcher Shedd, State Director of Vocational Education. Con-

Shedd, State Director of Vocational Education. Consistent with the CST membership principle, the Committee's members are training directors in the private sector, vocational and technical educators for all levels of public education, heads of propietary institutions, and leaders of job training programs.

The Committee's task is to monitor trends in advanced technology, develop interpretive materials, plan communication activities, provide technical consultation, and recommend funding priorities and projects. The Committee acts as a facilitator between the scientific and educational communities.

Regarding the advanced technology linkage, two activities merit elaboration. These activities address the questions "How is advanced technology monitored?" and "How is this information disseminated?".

All technology committees include at least two members from the Vocational Training Committee. These VTC members attend the technology committee meetings. There are three settings in which communication occurs (a) participation in deliberation of the technology committee, (b) informal interactive conversation with individuals and small groups (e.g. in social context), and (c) personal consultive contacts. In the technology committee deliberations, VTC members may direct questions to speakers and encourage lines of thinking among the technology committee members about educational implications. However, it is important to realize the advanced technology scientist is an information source, not a curriculum expert or program planner.

Thus, the critical function of the VTC member is to link the advanced technology with education planning. This function calls for understanding the changing technology and interpreting this information in terms of educational implications. Sometimes this task is very straight forward, other times it is complex. Let me illustrate by an example concerning artificial intelligence.

Even an elementary understanding of expert systems suggest two critical principles. First, the more complex the system, the greater the reduction in the labor force and knowledge needed among technicians who perform the original diagnostic decision tasks (Harris, 1987). This principle will argue for (a) shorter term specific training (one consultant, only slightly tongue in cheek, suggested training could be reduced from two years to two weeks) and (b) more comprehensive education in science, basic skills, and professional styles (e.g. attitude toward quality, team relationships, work ethic, etc.). This implication is straight forward. Second, developers of expert systems presently appear to bring one of two thinking approaches to their tasks. The confrontation of these styles is often counter productive to the creative process. Thus, by implication the question arises what can the educational system do to overcome these potential barriers to AI systems? On a more ethical and philosophical level should the educational system attempt to alter thinking styles? These questions go to the very root of educational principles. The issue of what to teach is elevated to the issue of how to teach and toward what goals. Content and process will once again be analyzed for their integration.

These examples suggest the types of information which can be obtained by the committee linkages. However, the linkage alone is not sufficient; thoughtful probing, careful listening, and critical interpreting are required of VTC members. Once ideas are developed, members report to the Vocational Training Committee. This Committee must filter and synthesize the information and determine its importance to education and training programs.

Information dissemination is an important Committee task. Initially, the Committee sponsored two statewide conferences for this purpose. A video tape of the initial conference's highlights was produced to be used in regional planning efforts, some of which have been held. While the conferences were well attended and received, the Committee's assessment of specific attainments was below expectation. Three major weaknesses were identified (a) the information was too general, (b) speakers had insufficient time to develop essential points, and (c) the relevance of the information to educational programming was not readily evident as presented.

The current dissemination plan is designed to overcome these limitations. Smaller, topically intensive workshops are envisioned. Topics will include specific advanced technology trends and implications and include substantial participant interaction. This approach should produce more prescriptive information. Workshops will culminate the Committee's synthesizing efforts and draw upon the information derived from advanced technology committee reports.

The Vocational Training Committee has a critical task, the linking of trends in advanced technology to educational and training programs. Clearly, its role is analytic and advisory.

Reflections

In the preceding sections, the organization and operation of the Corporation for Science and Technology in general have been highlighted and in particular the link between education and technology through the Vocational Training Committee has been developed. The paper concludes with some personal observations about these processes.

A tangible though unmeasured outcome of the Corporation for Science and Technology results from the on-going interaction among members of the private sector and educators. The dialogue involves wide ranging consideration of advanced technology. Since we are all in a speculative position, there is a genuine sense of brainstorming, creating, and analyzing. Through this process a sense of mutual respect for each other's expertise develops, and, I am confident a synergistic outcome is derived. The creative potential of this aggregated knowledge focused on the future is a positive and powerful force.

In my introductory remarks, a concern was raised about the adequacy and timing of change under older and established means of accommodating advanced technology. The approach described in this paper for addressing those issues appears promising. However, one can not say with certainty that the time required to implement curriculum change and accommodate new technology has been reduced with greater accuracy. At best a scheme has been implemented and we know it works to create new products and businesses. The process possesses interesting facets and there is clear policy direction and legislative support for the agency's agenda. One of the most important principles in this model's design is the purposeful involvement of educators, scientists, and government officials as equal partners in the dialogue of threats and opportunities.

The longer and more complex the dialogue processes, the clearer the need for a systematic approach to analyzing the impact of technology on education. The established "positivist" approach to generating knowledge through survey research has critical limitations such as poor timing and trend oversights. Clearly, new approaches are needed and researchers skilled in these new paradigms are essential. The interactive approach of probing and synthesizing described in this paper, while not sufficiently rigorous, points to important methodological ideas. Perhaps adaptations of the naturalistic paradigm (Lincoln & Guba, 1985), which is clearly a more systematic approach to interactive analysis could lead our field toward new power and timely insights.

Finally, one impact on the education participants in this process is clear. It can be simply put. One can not dismiss the likely impact of advanced technology on education while an active participant in a dialogue about it. The content is too powerful to ignore. There is not an educator on the committee who does not have that throbbing unanswerable question constantly on his/her mind "Are my programs relevant to the people I serve?". If you believe, as I do, that change cannot occur without leaders' commitments to change, then the idea behind the Corporation for Science and Technology does not leave change to chance.

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Notes

(1) Account from a class observation by the author in 1964.

(2) Report by Dr. J. P. Lisack of Purdue University to the Vocational Training Committee. Dr. Lisack is a noted manpower researcher.

(3) An observation developed by Mr. Richard Erdman, Director of Expert System Development as Magnavox Corporation.

Implications: Technological Literacy and Vocational Education Service Areas

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In attempting to relate technological literacy to vocational education there is one variable which educators, including vocational educators, should especially seek to address; that is the organization of learning experiences around SELF-CONCEPT as a vehicle to student understanding of both technology and their potential place in the technology-dominated workplace.

The link between technology instruction and occupational choice--and subsequent training--became a concern in the mid-seventies as career education peaked and as vocational education began to fund industrial arts for the first time. The field's response was to include mention of occupations and careers in textbooks and to offer instructional units in occupations related to industrial arts subject matter. Neither have been completely satisfactory as far as the vocational community is concerned.

The options available in various vocational service areas are still vague to students; there are still far too many students who switch from curriculum to curriculum in the vocational program. The bridge between technology education and occupational choice is difficult at best when we use occupations alone as the vehicle.

In the mid-seventies, an early seventh grade curriculum was introduced into the junior high schools of Virginia called "Careers and You". It was, and is, an attempt to enable students to relate to occupations via the frame of reference of "work environments."

The curriculum was based upon the "tentative selection" stage of career development. Among the goals of the experience were included:

> The investigation of several occupational styles and work environments found in the world of work, [and]
>
> The determination of the whereabouts of such occupational styles and work environments [within each career cluster or vocational areas].

In this approach, designed to alert students to their personal potential relative to career selection and to aid them in determining where appropriate occupational styles can be found, the cognitive subject matter becomes of lesser importance. The opportunity for students to simulate various occupational styles and roles becomes of primary importance. From this perspective, vocations can be examined to determine those occupational styles or modes of operation most prevelant or which most typify particular service areas.

There is much more to this curriculum, of course, but the work environment concept proposed by John Holland has potential as a vehicle to bring technology education and vocational service areas together. Holland hypothesized six work environments:

REALISTIC characterized by aggressive behavior; many times requiring physical skill.

INVESTIGATIVE characterized by organizing, thinking, and understanding.

SOCIAL characterized by interpersonal skills, caring.

CONVENTIONAL characterized by concern for rules, routine, self-control.

ENTERPRISING characterized by verbal skills, maniplating behavior.

ARTISTIC characterized by self-expression, indirect relations with people via art media.

It should be obvious that these work environments are not found in their "pure" form; that is, work involves us in a mix of activity, not simply one work environment. As an integral part of the curriculum under discussion, the SDS (Self-Directed Search) was used by students which gives one a profile of his/her affinity to all six environments. The fact that interests and aptitudes are an outgrowth of one's personality should give educators the first clue as to the need for an intermediate step between placing a menu of occupations before a young person and asking him, in essence, to select a vocational service area for training.

The Virginia experiment has several assets. . .as well as a few liabilities. Certainly the concept is acceptable to technology and vocational teachers. It does not threaten turf. The approach itself can be superimposed over any existing curricular organization with little or no disruption.

Finally, it can work. It can not only be used to relate activity to eventual occupational choice, but can be used by instructors to check on the comprehensiveness of their instructional methods as well: Am I teaching to only the students comfortable in the realistic work environment? Are students who have an affinity for the enterprising work environment being addressed? Those "turned on" by other work environments?

The approach also has two liabilities which seem obvious. First, it is limited as to grade level (the "tentative selection stage"); second, as a curriculum, it does not "belong" to anyone as do others and hence can become nobody's concern.

Yet, as a way in which to interface technology education and the vocational service areas, this conceptual frame of reference has some potential and should be considered as a supplemental approach.

Machine Vision Literacy

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Introduction

The Machine Vision Team is comprised of a diversified group of people who devote their time to solving industrial problems. Vision provides us with a large amount of information and enables us an intelligent interaction with the environment. Applying vision in industry allows for controlling of the process problem.

Definitions of the various competencies required to maximize career opportunities as a member of the machine vision team, assessments of the various titles used to discriminate between members and findings of the machine vision survey on competencies necessary at the technician, technologist, and engineering levels are presented. The initial competency list was subjected to the Machine Vision Education Committee on Certification. The Certification Committee is responsible for determining the competencies of the technician, technologist and engineer. This presentation provides the competencies which make up the certification criteria.

Machine Vision Team

We begin with the machine vision team because most work done in industry involves team effort. The team members include scientists, engineers, technologists, technicians and craftspeople. The team's activities center on problem-solving tasks. This requires that members constantly develop solutions to tasks within their team, or use the knowledge of others. Technology continues to accelerate at an ever-increasing rate as it develops one innovation after another. The new knowledge due to advancing technology directly affects the machine vision team. Requirements for many of today's jobs have already changed; however, people are unaware of the technological changes until they consider a job change.

Many are shocked when they do not possess the competencies for the new position. Projections of future jobs reveal a serious mismatch between the competencies for new jobs and the preparation of those seeking new positions. Many times displaced workers seem the logical candidates to fill the positions created by new technology, but when matching the position to the candidate, a lack of skills, knowledge, attitude and capability for retraining eliminate the displaced worker. The machine vision team requirements vary with each of the team members and their educational level.

The Scientist

The relationship between the positions of scientists, engineers, technologists, technicians and craftspeople are provided. Note that the scientist is the most theoretical member of the team, developing theory and laws from science. This investigation may require many years of study and may have very little application. Some scientists are labeled as applied or pure. Many of the presentations at "Vision 86" listed as research and developmental can be considered as applied activities carried out by applied scientists. These activities require a strong academic background and usually demand a Doctorate Degree. Machine vision scientists will need to continue their acquisition for knowledge throughout their working lives. The major competencies of the scientists are found in Table 1. With scientists, the "Scientific Area" will relate to the type of position and the tasks required.

The Engineer

Engineers apply the development of the scientists. These solutions to problems involve systems, procedures, product, facilities, human resources and finances. The solutions also require standards, specifications and requirements both internally and externally. The engineer is driven by the desire to develop a better way to accomplish a task in an attempt to maximize profit. Many "Engineering Areas" of specialization exist and require variations from one specialization to another. Since each area of specialization can also be divided into more sub-groups, the ability to specialize is related to the company's size.

A large number of people employed by industry are titled as engineers and do have a four-year degree. Companies have titled positions due to their tasks and training acquired by serving an apprenticeship, or gaining work experience and education through a variety of sources.

Recent movement in human development signifies that the title "Engineer" may only be given to graduates of accredited programs. The Accreditation Board of Engineering and Technology (ABET) accredits engineering, engineering technology and technology-type programs. Accreditation demonstrates that a program has met criteria established and evaluated by a peer team. Programs are provided that allow students the ability to gain the Bachelor's of Science Degree, Master's of Science Degree and Doctorate Degree. Many practicing engineers must comply not only with State requirements, but also with professional societies' requirements to become certified or registered.

Table 1
Competencies of the Machine Vision Scientist

- Mathematics Competencies
  - Algebra
  - Geometry
  - Calculus
  - Differential Equations
  - Matrix Algebra
- Science Competencies
  - Physics
    - Pure
      - Theoretical Diffraction
      - Theoretical Electricity
      - Theoretical Magnetism
      - Theoretical Matter
      - Theoretical Nuclear
      - Theoretical Optics
      - Theoretical Particle
      - Theoretical Quantum Mechanics
      - Theoretical Relativity
      - Theoretical Solid State
    - Applied
      - Diffraction
      - Electricity
      - Magnetism
      - Matter
      - Nuclear
      - Optics
      - Particle
      - Quantum Mechanics
      - Relativity
      - Solid State
  - Chemistry
    - Analytical
    - Biological
    - Inorganic
    - Interdisciplinary
    - Organic
    - Physical
    - Solid State
    - Geochemical
- Communication Competencies
  - English
  - Speech
- Additional General Education From:
  - Humanities, Social Science, Art, Music
- Science Areas
  - Biology
  - Botany
  - Chemistry
  - Physics

Table 2
Competencies of the Machine Vision Engineer

- Mathematics Competencies
  - Algebra
  - Geometry
  - Calculus
  - Differential Equations
  - Matrix Algebra
- Science Competencies
  - Physics
  - Chemistry
- Communication Competencies
  - English
  - Speech or Report Writing
- Additional General Education
  - Humanities, Social Science, Art, Music
- Machine Vision Engineering Competencies
  - Architectures
  - Comparison to Human Vision
  - Digitizing/Sampling
  - Evaluating Vendor Responses
  - Fundamental Concepts
  - Image Analysis
  - Image Processing
  - Image Segmentation
  - Lighting
  - Machine Vision Applications
  - Optics
  - Project Justification
  - Project Management
  - Three Dimensional Techniques
  - Sensors/Cameras
  - Writing a Specification

Table 3
Competencies of the Machine Vision Technologist

- Mathematics Competencies
  - Algebra
  - Geometry
  - Calculus
- Science Competencies
  - Physics
  - Chemistry
- Communication Competencies
  - English
  - Speech or Report Writing
- Additional General Education
  - Humanities, Social Science, Art, Music
- Machine Vision Engineering Technology/ Technology Competencies
  - Architectures
  - Comparison to Human Vision
  - Digitizing/Sampling
  - Evaluating Vendor Responses
  - Fundamental Concepts
  - Image Analysis
  - Image Processing
  - Image Segmentation
  - Lighting
  - Machine Vision Applications
  - Optics
  - Project Justification
  - Project Management
  - Three Dimensional Techniques
  - Sensors/Cameras
  - Writing a Specification

The Technologist

The Technologist is a four-year graduate of an engineering technology or technology program. Although similar in many details to the engineer, the technologist usually lacks depth in mathematics and science. The college and university programs are often titled "Industrial Technology" or "Engineering Technology". The tasks of the technologists are more applied than those of the engineers. This may require the debugging of machine vision systems, the installation of vision systems, or the feasibility of a vision system. Accreditation of these programs may be by ABET (Accreditation Board for Engineering and Technology) or NAIT (National Association of Industrial Technology) and may cover bachelor's, master's and doctoral programs in technology or engineering technology. Coursework will include a larger amount of laboratory work with skills in development and applied sciences. With the large number of two-year associate degrees, many students continue their education by transferring the sixty-plus hours toward the bachelor's program. The capstone, or 2 plus 2 programs, provide a vision system team member the ability to work and complete degree requirements at night. You may wish to refer to Figure 2, the relationships between the positions of scientists, engineers, technologists, technicians and craftspersons for a visual relationship.

The Technician

The vision system team members apply the skills and knowledge acquired by a specialized education or training program emphasizing manipulative skills. They often take courses with a core similar to all technologies and specialize in a field such as electronics, design, manufacturing, quality control, laser and robotics. Many of these programs provide competencies to fulfill a local demand and become very specialized. These competencies are acquired at a community college or technical college. Graduates complete an Associate of Applied Science or other associate degree and have a career path toward the technologist level with the 2 plus 2 type program. The need to verify research and development testing activities provides an ideal position for the technician. This also aids the other team members to better utilize their theoretical expertise.

The Craftsperson (Trade)

The crafts member of the team is certified as a craftsperson, usually completing a period as an apprentice and requiring a set period of years. In addition to the on-the-job training, the apprentice is required to complete related instruction offered by the Trade Association or by a local educational institution. Certification is accomplished by the United States Department of Labor, Bureau of Apprenticeship. These programs are very closely tied to unions which many times coordinate the related training activities. Electricians, plumbers and tool and die makers are several examples of the skilled trades which are recognized as craftspersons. The craftsperson becomes an important member of a team when the traditional components of a machine vision must be assembled. The craftsperson's skills provide the ability to manipulate the components into an integrated system and also debug the problems not eliminated during the engineering phase.

Table 4
Competencies of the Machine Vision Technician

- Mathematics Competencies
  - Algebra
  - Trigonometry
  - Geometry
- Science Competencies
  - Physics
  - Chemistry
- Communication Competencies
  - English
  - Speech or Technical Report Writing
- Additional General Education
  - Humanities, Social Sciences or above list
- Machine Vision Technician Competencies
  - Architectures
  - Comparison to Human Vision
  - Digitizing/Sampling
  - Evaluating Vendor Responses
  - Fundamental Concepts
  - Image Analysis
  - Image Processing
  - Image Segmentation
  - Lighting
  - Machine Vision Applications
  - Optics
  - Project Justification
  - Project Management
  - Three Dimensional Techniques
  - Sensors/Cameras
  - Writing a Specification

Table 5
Competencies of the Skilled Person

- Mathematics Competencies
  - Algebra
  - Trigonometry
- Science Competencies
  - Physics
  - Applied Sciences
- Communication Competencies
  - English and Report Writing
- Skill-Trade-Craft Area
  - Automechanic
  - Construction
  - Electrician
  - Glazer
  - Plumber
  - Sheet metal
  - Tool and Die

Conclusion

School is the most ideal place to begin an understanding of technology and the role it plays in our culture. Technology education students will be able to make an educated decision on the benefits of technology in our society. As a society people can and must control the development and application of technology.

Machine Vision Technology provides educators with an opportunity to apply science, mathematics, and technical concepts with applications in all fields. The Department of Technology at Northwest Missouri State University wishes to note the support from State of Missouri, Department of Elementary and Secondary Education; Micron Technology, Inc., Honeywell, Inc.; Microswitch Division, the Society of Manufacturing Engineers; Machine Vision Association, and the many people that provided information for this research.

Technology Education in New York State

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Introduction

The enterprise with which we have been involved in New York State is now four and one-half years old; it has involved the participation of literally hundreds, perhaps over a thousand individuals, has consumed thousands upon thousands of hours of time, and millions of dollars in financial resources; yet we are still in an evolutionary phase.

This endeavor, managed by the New York State Education Department, was known as the "futuring project" and stemmed from the desire to match curriculum to the needs of learners in the decades ahead. As a result, eight committees in occupational education and the practical arts were convened and were challenged to redefine their missions and clarify their goals.

This comprehensive review of educational programs began in 1981 and brought together educators, business and industrial leaders, social scientists, futurists, and engineers. New York State Commissioner of Education, Gordon Ambach, gave the committees their charge. The business and industrial leaders were asked to help identify what competencies were needed. The educational leaders were asked to determine how these competencies would be delivered. The committees deliberated for two and one-half years during which time experts were called upon to present papers, professional literature was reviewed, approaches debated, missions clarified, and a philosophic base was built.

Teachers from within the field were intimately involved in all phases of the project. A group of thirteen industrial arts practitioners (called regional facilitators) attended all committee meetings. These individuals provided ongoing liaison with the field through written correspondence and local meetings, and solicited feedback from the teaching constituency.

Futuring came at a time when the social climate was right for education about technology. It was the time of excitement about space shuttles and satellites; and there was a growing interest in technology in general.

It was the time when the National Commission on Excellence in Education stated at "our nation was at risk of losing its preeminence in science, and technological innovation."

And the National Science Board's report, "educating Americans for the 21st century," identified technology education as an entity; and recommended that a full year of mathematics, science and technology should be required each year in grades seven and eight. It was the time of Naisbitt's *Megatrends* and Toffler's *Third Wave*; and there was visible broad-based support for an educational response that addressed the need for a technologically literate population.

During this period, the transition within our own profession accelerated. The professional journal was renamed, *The Technology Teacher*, and the American Industrial Arts Association (now the International Technology Education Association), provided new leadership in assisting teachers to develop implementation strategies for technology-based programs.

The sense that there was indeed a professional support base, influenced the futuring committee to identify the inculcation of technological literacy as the paramount mission of industrial arts; and to recommend in January 1983 that the name "industrial arts" be changed to "technology education" in New York State.

While the futuring project was drawing up its recommendations, the New York State Board of Regents began work on its "action plan to improve elementary and secondary education in New York."

As a result of these parallel state-supported efforts, and the timeliness of the national reports, the Board of Regents saw fit to include a one-unit technology mandate as one of the middle school requirements.

Differences Between Industrial Arts and Technology Education

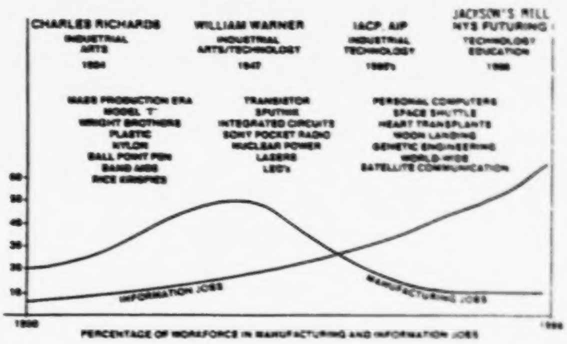
There are several major differences between technology education, and its predecessor, industrial arts. These differences relate to content base, methodology, and mission. The content base of industrial arts was based primarily on the inculcation of skills and knowledge in the use of tools, materials, and industrial processes. The content base of technology involves understanding generic concepts common to all technological systems (inputs, resources, processes, output, feedback and control).

The methodology of both programs relies upon hands-on, laboratory-based, "design and construct" activity, however, technology programs stress process rather than product. Problem solving and divergent thinking are fundamental skills which are carefully integrated into laboratory activities.

The mission of industrial arts was to prepare students for life in an industrial society. Manufacturing was the chief enterprise which underpinned the economy. The mission of technology education is to provide students with technological literacy in a knowledge-based, post-industrial society. Technological literacy transcends a knowledge of technological processes, and includes and understanding of technology within a social and economic context. (See Appendix A, Definitions) The transition from industrial arts to technology education is a logical evolution of the discipline.

INDUSTRIAL ARTS ——→ TECHNOLOGY EDUCATION

A LOGICAL EVOLUTION



Major Differences: Industrial Arts and Technology Education

	Industrial Arts	Technology Education
Mission	Teach about tools, materials, industrial processes,Provides technological literacy	
Conceptual Base	Undefined; teacher choice	Defined; major con-concepts and behaviors are ident- in state syllabus
Content Organizers	Discrete materials, or processes	System elements; inputs, resources, processes, outputs, feedback/control
Use of Project	Often used as an end in itself	Means to an end
Mental Process Skills (Problem Solving; Decision making, Creative thinking)	An informal program program element; occasionally overlooked	Planned as a formal element of program; entral to activity
Activity Base	75% hands-on; Unit Shop	75% hands-on; technology systems laboratories
Relationships to other disciplines	Philosophically yes; in practice, rare. Little formal attempt to match interdisciplinary concepts to industrial arts activity	Constants addressed in each activity; technology education is conceived as an integrating discipline

The Systems Approach

The most baffling questions that faced the futuring committee were "How do we teach about technology? What are its essential concepts, and how do we teach about a subject that is undergoing such rapid change?" For several months members of the committee explored these issues.

After intense professional discussion, the industrial arts futuring committee suggested a *systems approach*, which would incorporate hands-on learning activities similar to those which have made industrial arts so popular with students for generations.

Technology was viewed as being comprised of various systems and subsystems. We are surrounded by examples of these systems, large and small, such as hydroelectric systems, and automated production systems.

This general systems model can be used to point out the similarities that exist among all technological systems. If we can identify those systems concepts that are generic, *our students* will be better able to see familiar patterns reoccurring although the technologies themselves may be new to them.

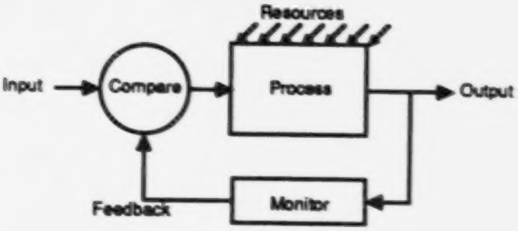
What is a System?

A system, simply stated, is a means through which we can accomplish our desired results. All systems have inputs, processes, and outputs. The *input* to the system is the desired result; the command which tells the system what to accomplish. The *process* is the action part of the system. It combines resources in response to the input command. It is the technical means we employ, the "how" component in the system. The *output* is the actual result. It may be the expected, desired result. The output also may include unexpected, undesired results. A system, consisting of an input, a process, and an output, is called an open-loop system.

An open-loop system. The process combines technological resources (people, information, materials, tools, and machines, capital, energy, and time) to produce an output in response to a command input.

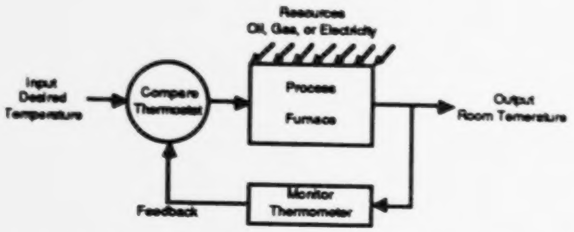
Closed-Loop Systems

How do we know if we get the output we want? We *monitor* the output, and derive "*feedback*." The feedback permits us to make a comparison between the desired result (command input) and the actual result (output). Once the comparison is made, we can adjust the process so that the system's output more closely agrees with the input.



General System Model of Closed-Loop System

The operation of technological systems (e.g. a home heating system), can be clarified through the use of the universal system model. In this closed-loop system, the input is the desired temperature setting. The process is the furnace which combines resources (like oil and electricity) to produce an output (the actual room temperature). A thermometer monitors the temperature and a thermostat compares the desired and actual temperature and adjusts the process (by turning the furnace on and off).



Conceptual Content Framework Based on the Universal System Model

A new vision for organization of technology education content may be borne out of the preceding analysis. Based upon the universal system model, curriculum may be generated which identifies elements which are generic to *all* technological systems. These elements are inputs, resources, processes, outputs, feedback, and control, and may be used to define content for technology programs in any or all of the cluster areas.

These universal system elements are integral to all systems, whether they are production, communication, transportation, biological, economic, or social systems. Understanding the common principles that apply to all systems can help students transfer knowledge from one specific occurrence to the next. Students will be able to see familiar patterns reoccurring although a particular technology may be new to them!

The System Model as a Content Organizer

The systems analogy can provide the *content organizers* for technology education program: the clusters can be viewed as technological *contexts* within which the systems operate.

The benefit of using the systems analogy is that it not only can be used to help students analyze familiar technologies, but can also be used to help them interpret previously unencountered technologies as well.

A robotic material transport system might be a technology new to most students. The systems model can help explain this technology.

The input (desired result) is to move material to a desired position. The process involves the robotic arm and its motors; the output is the actual position of the material. A sensing device, perhaps an optical sensor, monitors the position. The comparison between the desired position and the actual position is made by a digital computer. The computer adjusts the process by sending a signal to the motors in the robotic arm.

The systems analogy can be used to model virtually any technological system, and therefore, can be used as a means through which content can be organized for technologies such as manufacturing, construction, communications, or transportation. Consistency can thus be achieved in the way subject matter is presented. Transfer of learning will thus be facilitated for students.

Problem Solving as a System

Those of us who have ever taught 7th grade recognize that we will have only a modicum of success if we depend upon drawing systems diagrams on the blackboard. We must do what we've always done in good industrial arts teaching; that is, provide the students with an activity, and then elicit the concepts from their own base of experience.

In this case, the students were presented with a technological design problem to design a rubber-band powered vehicle which could carry a raw egg safely over a distance of seventy-five feet, at a speed greater than that of any other competing group's vehicle.

The students were encouraged to do a lot of trial and error, testing, and crative problem solving. . .and to refine their design until it worked the way they wanted it to.

It is well accepted that these kinds of investigative activities are an excellent way to stimulating higher level mental process skills, like decision making, and critical thinking; but this problem solving experience is really an expertise *in systems thinking*, and serves to introduce the students to systems concepts.

We can look at the problem solving process in systems terms: the input was the goal, or what the student wanted to accomplish. The process consisted of generating, selecting, and implementing alternatives; and the output was the actual result.

What systems thinking can do for the student, is to help them develop a problem solving routine, and to create the perception that we don't have to be satisifed with the initial results. We use our failures to help us improve our performance.

Thus, the basic systems model becomes a simple conceptual tool that the student can picture easily and employ to assist in the solution of problems and in the analysis of technical systems.

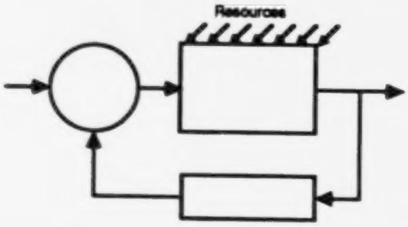
Conceptual Curriculum Framework

The systems analogy provides the content organizers for the New York Technology Education Program. At the seventh grade level, the resource inputs, systems, and impacts of technology serve to provide structure. Several contexts are suggested from within which examples might be drawn. These are systems in biotechnology, communications and information technology, production technology, and transportation technology.

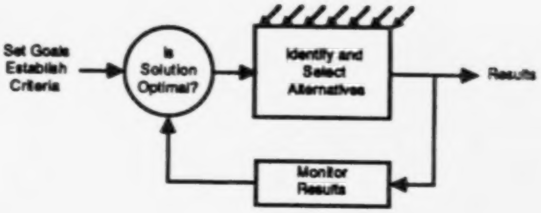
Seventh Grade Program

Module 1 introduces the student to this new field of study, addresses the evolution and importance of technology, and focuses on reasons why people must study about technology. Students should know that technology influences their routines and satisfies human needs. They should know that technology predates science; that before the science of chemistry, people were making glass.

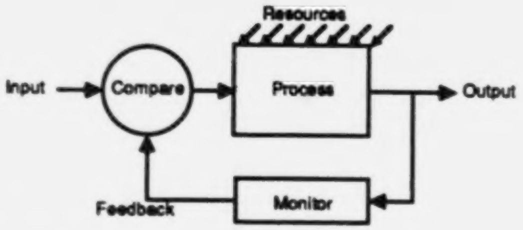
Module 2 focuses on the seven resources which are generic to all technologies. Whether we are referring to ancient technologies like flowing, or ultramodern technologies like satellite communication, the resources of people, information, materials, tools and machines, energy, capital, and time, are required.



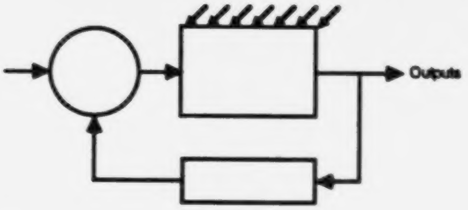
Module 3 is a problem solving module where students could be challenged to solve a prescribed technical problem, design a device for a handicapped person, or participate in a competitive problem solving event. It serves as a natural introduction to the systems module, since when people are solving problems, they are working within a system.



In Module 4, students are introduced to systems terminology at this point. Inputs, processs, and outputs are studied. The concept of feedback is lightly introduced.



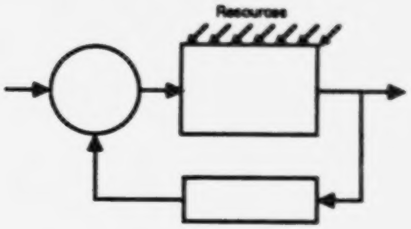
Module 5 focuses on the positive and negative impacts of technology. (The outputs) as well as the match between technology and the environment, and technology and the human user are illustrated.



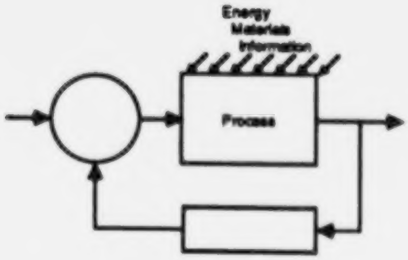
The Eighth Grade Program

The eighth grade program "closes the loop" in our technology model.

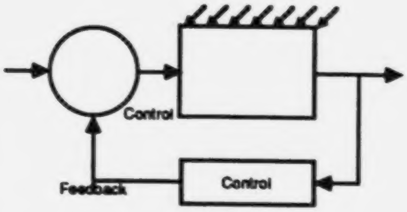
Module 6 revisits the resources for technology, however, emphasizes the choices people may make in selecting resources.



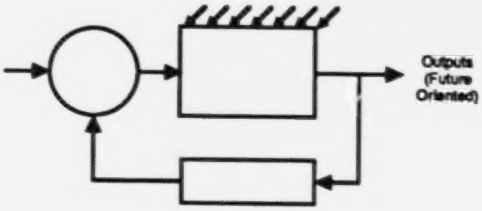
Module 7 addresses the process component of the system and looks at three types of processing: processing energy, materials, and information.



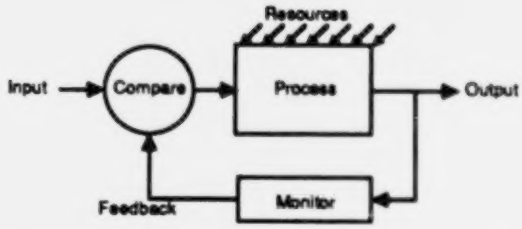
Module 8 introduces concepts of sensing and control. Thus, the feedback loop is studied. Concepts of open and closed loop control are introduced.



Module 9 is a look to the future. Students look at future impacts of technology, from a global perspective. The student is placed at the center of a time continuum from his or her grandparents era to the time when the student will most likely be a grandparent, and is asked to discuss the changes in technology that have or may occur during that period.



Module 10, the final module, illustrates how the systems model itself can be used as a problem solving tool. Students are encouraged to use systems thinking to design a system. It is in this module that students are encouraged to synthesize their new knowledge in the creation of a functioning technological system.



Technology Learning Activities

One of the most unique facets of the New York program is the evolution of an activity format known as the Technology Learning Activity (TLA). The TLA serves two major functions: first, concepts are identified and become the driving force behind the choice of the activity. Thus, a match between major concepts and student activity is assured. Second, the TLA's identify a series of "constants," among which are those that directly relate middle school mathematics, science, and social studies concepts to the study of technology. These concepts have been specifically identified by subject matter specialists.

The constants serve to provide genuine interdisciplinary connections to other school subjects, the world of work, and to life's experiences.

There are ten constants which have been identified within each TLA. They include: systems, mathematics, science, social science, safety and health, psychomotor skills, communications skills, problem solving, career related information, and transfer of learning. Attention to the constants epitomizes the essence of technology education. A distinct emphasis is placed on the interdisciplinary nature of technology as an integrating discipline.

Presently, several dozen TLAs have been generated. Among them are the following:

Time, The Fourth Dimension (Module 1) - Students construct samples of time keeping devices (e.g. sand, water and candle clocks, sundials, burning rope clock, etc.) that reflect the evolution of time pieces.

Logo Design (Module 2) - The seven generic technological resources are represented by a logo which the students design, and reproduce as buttons, or on silk screened T-shirts.

Mouse-Trap Powered Vehicle Design Problem (Module 3) - Working inteams, students will design and build a mouse-trap powered vehicle. One hundred dollars in play money will be given to each team. A basic bag of parts is purchased for twenty-five dollars. Additional parts and tools may be purchased for additional money. A distance competition is held and results discussed. The winning vehicle is the one which is most cost-effective.

Systems and Subsystems in Model Rocketry (Module 4) - Students will construct, pre-flight test, launch, and measure baseline and flight altitudes of model rockets and analyze the component systems and subsystems.

Hydroponic Greenhouse (Module 5) - Prototypes of hydroponic greenhouses will be constructed as a means of exemplifying how technology can be better adapted to the environment.

Optimizing Resources in Transportation Systems (Module 6) - In this TLA, students will identify resources that can be replaced by others in order to optimize a transportation system.

Material Processing: Drying Foods for Preservation (Module 7) - Students process various fruits, vegetables, nuts, spices, by subtracting moisture from the foods. A variety of drying processes are used, comparisons made as to cost, effectiveness, and efficiency.

Controlling Technological Systems (Module 8) - Sensing and control concepts are studied through the use of toys such as armitron robots, and feedback games.

The Committee on World Repair (Module 9) - Students will identify a variety of global social issues which parallel the growth of technology, will propose alternative technological solutions, and physically model one solution.

Clean the Air (Module 10) - Students will apply previous technical knowledge to the design of a system to remove air pollution from a room. The original set of TLAs was developed by a group of select technology teacher-trainers as part of an intensive three week inservice workshop at Oswego University during the summer of 1984. These TLAs are designed to serve as models for teachers who are encouraged to develop their own. Presently occurred during the 1984-85 school year involved the generation of the second part (the eighth grade portion) of the syllabus. A planning group comprised of five project leaders met to develop the framework for the eighth grade syllabus.

The planning group members served as team leaders for 3-4 person satellite curriculum writing teams. Each team was met often to assess work in progress, and to ensure continuity among the writing teams. The entire group of curriculum writers met three times during the curriculum writing process to present its work to the group at large, and to receive feedback.

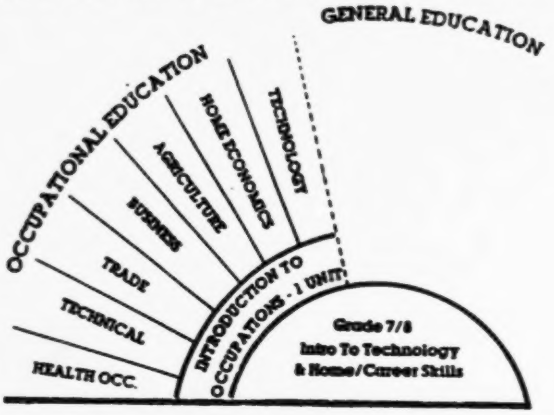
The eighth grade portion of the curriculum has been twice field tested across the state. Reaction was formally solicited, and resulted in a syllabus revision which will be distributed to teachers before the 1987-88 school year begins. Full implementation of the program has occurred for grade seven student in September, 1986, and will occur for grade eight students in September, 1987. The Commissioner of Education and New York State Board of Regents have mandated that one year of technology education must be taken by all students who complete the eighth grade by June, 1988.

Technology and Occupational Education

Technology education is an integral part of the occupational education continuum in New York. A coordinated curriculum has been generated which views the introduction of technology program (along with another course entitled home and career skills) as providing occupational educational core competencies at the middle/junior high school level.

As a component of all high school occupational education sequences, students must take two required introduction to occupation courses (personal resource management, and the working citizen).

Students may fulfill graduation requirements in attaining sequence credit in any of several occupational education programs including agriculture education, business education, health occupations education, home economics education, technical education, technology education, or trade and industrial education. The high school technology program is viewed as providing core skills for students pursuing further experiences in technical education, and/or grade and industrial education.



TECHNOLOGY EDUCATION AS PART OF
THE OCCUPATIONAL EDUCATION CONTINUUM

Inservice Training

Over a period of four years (1984-1987), approximately 1300 industrial arts teachers have been trained by the New York State Education Department's Technology Teacher Training Project. A superb corp of 40 technology teacher trainers has devoted many weeks to intensive study of the syllabus and to the generation of technology learning activities to support its delivery. These teacher trainers have dispersed across New York state to provide local inservice training to groups of industrial arts/technology teachers at 19 regional centers. The teacher trainers have provided the critical functions of translating a theoretical document into an activity-based program, developing implementation strategies, and communicating the feasibility of the entire approach to their peers.

The professional commitment that has been displayed by the teachers themselves is astounding. The regional inservice programs were entirely voluntary, required between one and two weeks of summer attendance, and did not offer financial support to the teachers.

Teacher Reaction to the Program

The technology education program is a significant departure from traditional industrial arts. Teachers therefore have been challenged to assimilate new content, new procedures, and accept a new conceptual base for their discipline.

The teacher trainers report that the overwhelming majority of the teachers who have participated in the inservice program have additional contributions. Attending teachers were encouraged to view the curriculum as *dynamic*, and therefore felt free to *suggest changes*, many of which were incorporated into the approximately 125 TLAs in various stages of completion during the first year of field testing. The commitment to the new program appears to be quite solic among those who have participated in the inservice sessions.

There remains a corps of teachers who have not had the opportunity to study the new material, and therefore have not had the benefit of the sharing and support of colleagues. Among that group there are mixed perceptions. Some have heard good things from their fellow teachers and are receptive, while others remain committed to more traditional approaches.

The technology fair, held at the New York State Technology Education Association's annual conference last spring, was inspiring. Field testing teachers displayed computer controlled hydroponic gardens, exhibited time keeping devices used to teach the evolution of technology, and an impressive array of problem solving activities.

This has not been an easy road. There have been challenges right from the beginning: this has been a radical upheaval for many of us. Technology education represents a substantial departure from traditional industrial arts and involves quite a new content base.

But those involved in the technology movement share a vision that has united our profession. The comraderie that exists can only be felt by those committed to a common cause.

No one ever promised us that change would be easy in our profession, but the changes have come from teachers from within our own discipline. We have not forgotten that it is industrial arts that has breathed life into the technology education movement in this country, and much of what will sustain technology education is the best of our present practice.

I believe that we are in fact, evolving a new discipline. Very few educators are provided with that consummate opportunity during their careers. And I believe that we are to be envied.

Appendix A

Basic Definitions

TECHNOLOGY: The use of accumulated human knowledge to process resources to satisfy human needs and wants.

TECHNOLOGY EDUCATION: An integrating discipline designed to develop technological literacy as part of all students' fundamental education, through an activity-based study of past, present, and future technological systems; their resources, processes, and impacts on society.

TECHNOLOGICAL LITERACY: The ability to use, maintain, design, construct, analyze, and assess the impacts of technological systems.

TECHNOLOGICAL SYSTEM: A means of accomplishing a desired technological result by processing resources in response to a command input. A system may be open-loop (feedback) or closed-loop (using feedback).

Technological Literacy: Roles for Practical Arts and Vocational Education

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The educational establishment of this latter part of the twentieth century is beset by a task that has had no parallel in the history of humankind. This task is to educate a generation of citizens who would not be strangers in a world they have inherited, as well as having had a part in its shaping. The central issue is one of technological literacy for practically all persons living in a democratic society that is so profoundly impacted by technology in every aspect of the human's existence.

Literacy, as a concept with respect to Technology, is a dynamic phenomena in itself. That is to say, technological literacy is an ever-changing quality that is dependent on time, place and conditions.

The *factor of time* creates its own unique dimension of literacy when we speak about technological literacy. The agrarian society, the industrial society, the post-industrial society, and the super-industrial society, all operating within given time frameworks, provide for a dynamics of literacy in relation to the state of the technology in each.

The *factor of place* plays an important role when one takes into account the tremendous variation in technological developments as experienced by the citizens of Silicon Valley, the City of New York, the Third World countries of Africa, or the primitive tribes of New Guinea in the year 1987.

The *conditions factor* brings into play the circumstances in which a given group or society live or carry out their livelihood. Such varying conditions may be identified as one views the life styles of the astronaut, the wandering nomad of Saudi Arabia, or the boatpeople of Hong Kong, all living in the year 1987.

Technological literacy in the present age here is these United States is as fundamental to human functioning as is the need to read and write. It is basic to human performance in practically all areas of living, as well as the very existence of the individual on this planet.

Technological literacy is so encompassing in its scope that there are no areas of the human's existence that are not under its pervasive influence. Technological literacy is a universal requirement that reaches into all sectors of society and all levels of human activity.

The earlier concepts of literacy, centering around reading, writing and calculating, were largely one of skill or task development. The issue of technological literacy reaches into every dimension of human involvement, ranging from skill development, manipulation, broad understanding, philosophical positioning, ethical and moral consideration, and attitude formulation.

There are two important concerns at the heart of the issue of technological literacy. The first is a concern for effective citizenship in a democratic advanced technological society wherein the individual can feel some sense of control as well as contribution and accommodation. The second major concern is for the future,--the nature of a world that our future generations will inherit, since humankind now has the technology to design the kind of a world that is wanted. The human, for the most part, is no longer at the mercy of the elements (natural and man-made) as was the case with earlier generations. Advances in technology in a broad range of fields have put the future to a much greater degree in the hands of the humankind.

Technological literacy is based on the concept of understanding and not the possession of artifacts of an advanced technological age. "Technological literacy is the possession of a reasonable understanding of the behavior of technological systems and requires knowledge of scientific and mathematical concepts" (NSF, p. 74). Technological literacy instruction must help "people understand the limitations as well as the capabilities of emerging technologies. The technologically literate person should have a sense of what technology can and cannot do. He or she should not believe that technology can solve all ills, nor that technology is responsible for most problems" (NSF, p. 74).

The publication, *Educating Americans for the 21st Century* (NSF, 1983) contains the statement:

> Technological literacy needs to be a part of general literacy and "numeracy." In a sense, we are speaking of "basics" in education, and we are identifying the knowledge and understanding of technology as basic. . . (NSF, p. 73).

Technological literacy is an area of literacy that extends across practically every discipline in the secondary school program and as such, it's pursuit in our schools must include strong implications for mathematics, science, history, economics, social and environmental impact, as well as the areas of technology education, practical arts and vocational education.

The cross-disciplinary and multi-disciplinary nature of technology as an area of study was expressed by Truxal (1986) as follows:

> Technology, after all, (in the present setting) is simply the application of scientific knowledge to achieve a specified human purpose. As technology is directed toward a societal goal, every new technology involves questions of ethics and values, which must be judged from aesthetic, historical and philosophical viewpoints. Furthermore, technological change has economic, sociological, and behavioral implications for both the country and those individuals directly involved. (p. 12)

Thus, knowledge of technology becomes fundamental in this latter part of the twentieth century. Life and living in this technological society demand a literacy--an understanding that makes technological literacy an imperative.

The National Science Foundation report, *Educating Americans for the 21st Century* (1983), lists five important areas of understanding that would contribute to technological literacy. These areas of understanding are:

> 1. The historical role of technology in human development,
>
> 2. The relationship between technological decisions and human values,
>
> 3. The benefits and risks of choosing technologies,
>
> 4. The change occurring in current technology, and
>
> 5. An understanding of technology assessment as a method of influencing the choice of future technologies. (p. 74)

The above five areas of understanding provide a framework within which the practical arts and vocational education can function.

* The historical role of technology has been an integral part of the industrial arts/technology education program in the study of early innovations on the anthropological unit approach (Maryland Plan, 1973).

* The relationship between technological decisions and human values can be integrated into the practical arts and vocational education as the respective professions deal with such areas as housing and construction, transportation, communications, power, energy and manufacture. Human values enter into the application, purchase, use, maintenance and selection of technologies within each of the areas listed.

* The benefits and risks in choosing technologies can be dealt with in the practical arts and vocational education by including these two elements (benefits and risks) as additional areas of concern when studying the respective trade areas as well as the areas listed for the practical arts. There are few technological areas that can not be subject to the scrutiny of benefits and risks.

* The changes occurring in current technology is an area of literacy directly applicable to every service area of vocational education, as well as the previously mentioned construction, manufacture, power, energy, communications and transportation. The instructional plan or strategy should include an emphasis on such changes as well as their impact.

* An understanding of technology assessment as a method of influencing the choice of future technologies is another area of technological literacy in which the practical arts and vocational education can make a contribution. The broadening of instruction in the practical arts and vocational education may well include discussions and analyses of the merit or lack of merit of the technologies involved in the program. Such analytical examination of the technologies provides a whole new dimension for literacy which may lead to more effective decision making. It might also involve raising the right questions, such as:

> What are the alternatives?
>
> What are the social impacts?

What are the environmental impacts?

Who should be involved in the decision?

What are the principles of science and/or math involved?

What role has the technology or innovation played?

What are the ethical, social, oral and legal issues associated with or brought into play by the technology?

The role of the practical arts and vocational education in the development of technological literacy is one that may be plotted along a continuum ranging from relatively small or insignificant to a broad and encompassing function. The determining factor is largely a matter of perspective, as well as choice and commitment on the part of the profession.

The matter of perspective is related to a number of issues that the profession must face or resolve.

1. Is the profession interested in being a vital component of the education of all students or is it concerned with a limited constituency?
2. Is the profession interested in being an integral part of an interdisciplinary involvement with the total school and community?
3. Is the profession willing to broaden its scope of content to include the dimensions of literacy that extend beyond the parameters of the traditional practices and limited craft activities?

A Unique Role by Virtue of Setting, Process and Content

A unique role that technology education, practical arts and vocational education can play in technology literacy is related to the nature of the instructional setting, as well as the kind of instruction that can be carried out in each of these fields.

The instructional setting contains many of the tools, materials and equipment associated with the technology of such areas as communication, power, energy, medical science, construction, manufacture, transportation, business and agriculture.

The opportunity for students to have concrete, first-hand experiences with the tools, materials, and processes of an advanced technological society provides the fields of technology education, practical arts and vocational education with unusual opportunities to contribute to the technological literacy of the students.

The experiential nature of instruction, as carried out in technology education, practical arts and vocational education, adds a whole new and important dimension to the development of technological literacy. It is that dimension of reality with respect to what is being studied, and also to the realities of the world beyond the school. The programs in technology education, practical arts, and vocational education provide a unique setting in the modern school for the integration of mathematics, science, social studies, economics, history, art and environmental studies. It is a setting conducive to a holistic study of technology as opposed to the atomistic approach so characteristic of much of one's education.

A Place in the School to Put It All Together

Another very important role that technology education, the practical arts and vocational education can play is serving as a point in the school where the student can put it all together in the context of the world beyond the school.

Such areas of instruction can provide the setting where mathematics can be applied in the world of reality with concrete applications of principles and concepts. The principles and concepts of science are used to explain and interpret the phenomena of heat exchange, power transmission, forces, lift, drag, friction, and numerous other realities of the technologies associated with the area of Industrial Arts/Technology Education and Vocational Education.

In addition to science and mathematics principles and concepts, the Industrial Arts/Technology Education and Vocational fields abound in the opportunities to deal with the social impact and the environmental impact of many of the items studied in the laboratory instructional programs.

This plea for a place in the school where the student can put it all together is supported by a comment by Alfred North Whitehead (1952) in the following quotation:

> The solution which I am urging is to eradicate the fatal disconnection of subjects which kills the vitality of our modern curriculum. There is only one subject-matter for education, and that is Life in all its manifestations. Instead of this single unit, we offer children--Algebra, from which nothing follows; Geometry, from which nothing follows; Science, from which nothing follows; History, from which nothing follows; a couple of languages never mastered. . . It is a rapid table of contents which a deity might run over in his mind while he was thinking of

> creating a world, and had not yet determined how to put it together. (p. 18)

Later on in the same writing, Whitehead summarized the need in education by stating that ". . .The pupils have got to be made to feel that they are studying something and not merely executing intellectual minutes (p. 21).

That setting, that place in the school and the program areas, are most appropriately in the fields of Industrial Arts/Technology Education and Vocational Education. The professions in these respective areas need to broaden their focus of what is obviously possible in their instructional settings.

The Process Skills Required of the Future Citizen

A third role that the areas of Industrial Arts/Technology Education and Vocational Education can play in developing technological literacy must be seen in the larger context of current and future educational thought. These are with respect to the development of skills in the processes of problem solving, inquiry, synthesis, analysis and decision making. These skills are the skills of the future. They will require new emphases and new perspectives on the nature of schooling and its function in a highly accelerated changing world.

All of the ingredients for such human potential development exist in abundance in the world and processes associated with the fields of Industrial Arts/Technology Education and Vocational Education. The essential concern must be one of how the student gets the answers rather than the answers themselves, for as we all know, the answers will change.

Bridging the Gap of Technological Ignorance

One of the most important roles for Industrial Arts/Technology Education and Vocational Education in their involvement with technological literacy certainly must be the contributions they can make in helping the citizen achieve a greater understanding of the technological society in which he/she must function. This increased citizen role goes beyond that of career information, work skills and those attributes of a successful employee. The new dimension is in the broad arena of technological literacy, wherein the future citizen can make effective decisions about technological alternatives, the merit of one technology over another, and the application of technologies in the solution of major problems in the community, the nation and the world. The citizenship contribution issue is brought into focus as one considers the responsibilities as well as roles, for those of us who have the great privilege of being citizens in a democracy that also happens to be one of the most advanced technological nations in the world. This important citizenship role has caused some of our educational and public leaders to see what has been happening in our schools with respect to the need for technology studies.

There have been numerous concerns about a society that has given little direct attention to the study of technology in our public secondary schools. Boyer (1983), in his book, *High School: A Report on Secondary Education in America,* wrote: "We are frankly disappointed that none of the schools we visited required a study of technology. More disturbing still is the current inclination to equate technology with computers" (p. 111).

This lack of attention to the study of technology has implications for a concern that sees a growing chasm or gulf that tends to separate the technologists from the population in general. John Slaughter, a former Director of the National Science Foundation, quoted in the publication, *Educating Americans for the 21st Century* (1983), warned of the growing chasm between a small scientific elite and a citizenry ill-informed, indeed, uninformed on issues with a science component" (p. 10).

Maley (1969), in a presentation at the 1969 convention of the American Vocational Association in Boston, made the following comment: "The brighter tomorrow will be there only if a bridge can be designed that would span the gulf of technological ignorance which exists between the vast majority of the populace and the technical elite" (p. i).

This position has been supported by a number of citations warning of the consequences of the gulf of ignorance that appeared to be so obvious some twenty years ago. Walter Finke (1967) pointed out that the gap between the technologist and the populace in general was a concern of Sir Charles Snow when he said:

> . . .that he feared that technological progress would eventually lead to a situation in which life-or death decisions would one day be made by a small scientific elite 'who do not quite understand what the depth of the argument is'.
>
> That is, he said, 'one of the consequences of the lapse or gulf in communication between scientists and on-scientists'. (p. 50)

A similar concern was expressed by Barbara Ward (1966) in her text, *Spaceship Earth*, in which there is a concern for the impact of technology and the control of political and economic policy.

> In a world that is being driven onward at apocalyptic speed by science and technology, we cannot, we must not, give up the idea that human beings can control their political and economic policies... (p. 1)

Perhaps an even more pointed element was contained in the report from the Commission on the Year 2000 that appeared in an article by Andrew Squibb (1968) in *The News American* (Baltimore). The report projected:

> The end of democratic government as people lose interest and leave the decisions to an intellectual, technological elite. (p. F-1)

Thus, I would propose that the practical arts and vocational education take up the challenge of doing their share in narrowing that gulf of ignorance that separates the technocratic elite from the citizens in general. This is not a task that can be accomplished by these areas alone. There are, however, very important roles that they can and must play.

The Consumer, User and Producer Literacy Needs

Other roles for Industrial Arts/Technology Education and Vocational Education are related to the contributions that these areas can make to the individual as a consumer and user of the fruits of an advanced technological society. The tools, processes, systems and equipment available to the individual call for a form of consumer understanding that is highly dependent on technological literacy.

Likewise, the user of technology in practically every area of living--work, play, communication, travel, food preparation, home maintenance, and health, all require the individual to have a level of technological literacy unprecedented in human history. The areas of Industrial Arts/Technology Education and Vocational Education have a significant role in this, the consumer and user functions of the individual.

The producer role is one that, in today's workplace, will require increasing sophistication in the area of technological literacy. Vocational education has a great opportunity for contributing to the individual's technological literacy as well as his/her capability in using the technology as tools in a productive, wage-earning capacity.

Technological Literacy and the Need for Continuous Literacy Development

Technological literacy is not a one-shot deal, wherein a student has taken a good program or series of courses contributory to technological literacy. The requirements for technological literacy will remain with the individual throughout his/her working or useful life. This has grave implications for what we do in education in this latter part of the 20th century.

That is to say--*the processes* by which the individual is able to maintain a reasonable degree of technological literacy throughout one's life in an everchanging technological society is one of education's greatest challenges.

The picture is one of the individual moving through a life of changing environment, changing human requirements, and certainly, changing technologies. The picture gets more complicated by virtue of the fact that it is reasonable to expect that the pace of the two entities, i.e. the individual and the technological society, are not the same, as one seems to outdistance the other.

The past forty years have seen a technological explosion outpace and outdistance the population of this nation in its ability to even be a reasonable competitor in the race. The increasing gap between the individual's understanding and the state of technological affairs continues to widen and will continue to do so in the forseeable future.

But now you say: "What does all of this so-called race of the human with the state of technological affairs have to do with the *role* of the practical arts and vocational education in dealing with technological literacy?" I would reply that there is an extremely important role that such educational programs can and must play. Earlier, I made the comment that--the processes by which the individual is able to maintain a reasonable degree of technological literacy throughout one's life in an ever-changing technological society is one of education's greatest challenges. The word "processes" is the key to a much closer race. The "processes" in this case are the *processes of learning*. Alvin Toffler (1970) best described the condition and the requirements in the comment: "Tomorrow's illiterate will not be the man (person) who can't read; he will be the man who has not learned to learn" (p. 367).

Thus, I would propose that one of the most important roles for the practical arts and vocational education is to assist each and every student in their ability to learn. To do less would be to educate for obsolescence in a fast changing in technological society.

A First-Hand Experience Leading to Technological Literacy

Furthermore, I would contend that the practical arts and vocational education have one of education's most fertile gardens for developing the individual's ability to learn. The environment, as well as the context, in which such learning takes place is conducive to a broad range of learning styles. It is also the setting for a multi-sensory, multi-dimensional learning that emanates from a first-hand encounter with the technology and its principles of mathematics, science, social and environmental impact. The importance of this first-hand experience in the learning process was the subject of a comment by Alfred North Whitehead (1952) in his concern for a "basis for intellectual life."

> . . .First-hand knowledge is the ultimate basis of intellectual life. To a large extent book-learning conveys second-handed information, and as such can never rise to the importance of immediate practice. . . .What the learned world tends to offer is one second-hand scrap of information illustrating ideas derived from another second-hand scrap of information. The second-handedness of the learned world is the secret of its mediocrity. (p. 61)

The role of helping students to learn how to learn is one that is enhanced in the practical arts and vocational education by virtue of the environment, the direct involvement with the technology, and the use of technology to study other technologies.

The development of programs in the practical arts and vocational education with a high degree of effectiveness in achieving greater technological literacy may be one of our greatest challenges--and at the same time, it may be our finest opportunity.

As to the role or roles that the practical arts and vocational education can play in the development of technological literacy here in the United States,--it is a matter of perspective of the roles they can play. It also is a matter of choice and commitment on the part of the respective professions.

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Technological Literacy: The Role of Vocational Education

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This paper will begin to explore the role of vocational education in developing technological literacy. To accomplish that end, the paper will, first, briefly examine the evolving concept of technological literacy. Second, it will review the present status of vocational education, particularly at the secondary level. Finally, the paper will attempt to answer the questions, "Should the twain meet, and, if so, how?"

Technological Literacy

The development of technological literacy is not a new idea for industrial arts educators. William Warner and his students began studying the idea in the 1940's (Warner et al., 1965). One of Warner's students, Delmar Olson, completed a dissertation in the '50's which outlined a structure for the study of technology and advocated that industrial arts adopt a curriculum that would reflect the technology (Olson, 1963). But the great surge of curriculum activity in the '60's ignored technology. Towers, Lux, and Ray's "Industrial Arts Curriculum Project," Face and Flug's "American Industry," Maley's "Maryland Plan," Yoho's "Orchestrated System," and Stadt's "Enterprise" (to name just a few) were all designed to improve the ability of industrial arts to interpret *industry*--not technology. The interpretation of industry rather than the development of technological literacy was accepted as the dominant purpose of industrial arts education.

Why was the study of technology and the development of technological literacy ignored then, but is now being urged upon industrial arts educators? Certainly it is not because industrial arts educators have debated and explicitly chosen to shift the philosophical orientation of the field from its traditional student-centered, humanistic approach to a subject/society-centered approach based upon academic rationalism (Zuga, 1985). Despite some serious study of the subject by Paul DeVore (1980), it is certainly not because practitioners better understand technology and how to teach it now than they did then. The most logical explanation for the motivation to change is the desire for survival--the need to fit better into the new wave of educational thought and practice, epitomized by the emphasis on the new basics. Industrial arts educators are being driven to don a mantle of greater academic respectability.

Despite the self-serving motivation, a change from industrial arts and interpreting industry to technology education and developing technological literacy is not irrational. It is not difficult to argue that it is important for all youth (general education) to understand technology in a society driven in large measure by technology. Further, the change can be made with relative ease: (a) the traditional laboratory, multisensory, activity-oriented approach can be retained; (b) a more credible claim can be made for reinforcing a wide variety of mathematical and scientific concepts and for enhancing problem solving and creative thinking skills; and (c) the curriculum clusters, which grew out of earlier industrial arts curriculum projects and which were further developed during the career education years, can be adapted as content organizers for the study of technological systems.

But several important questions remain to be answered if the change to technology education and the development of technological literacy is to be successful. Greater concensus is needed about the meaning of technology and of technological literacy. The justification for this conference, and the focus of every presentation in it, is to explore these concepts and to begin to build that concensus.

What is Technology?

There are many definitions of technology; it is useful for industrial arts/technology educators to think of them in four categories. Each category reflects a different breadth of potential content.

The definitions of technology included in the first category reflect the broadest interpretation of potential content. These definitions consider technology as systems for making and doing things--all the way from making machinists to making love. J. Kenneth Galbreath's (1967) use of the term provides an exemplar: "Technology means the systematic application of scientific and other knowledge to practical tasks."

The definition in the second category are narrower in scope. They speak of technology as systems (or adaptive means) for enhancing the capacity of society to produce goods and services. The definitions limit the systems to those involved in the production of goods and services, but do not restrict the systems to those associated with "industry." Medical and agricultural systems, for instance, are included in the scope of content identified by this category of definitions. The Technology Act of 1986 defines technology in this manner (100th Congress, 1986).

The third category contains definitions that limit the systems to those which enhance the industrial capacity of society--industrial technology. These definitions typically organize the systems into such components as communication, manufacturing, construction, transportation, etc. The Jackson's Mill document reflects this more limited interpretation of technology (Wright, 1987).

Fourth, and finally, a few definitions interpret technology as computer (or as electronic communications systems). These are obviously the most limited of all.

What Knowledge, Skills and Attitudes Comprise Literacy?

The goal of developing technological literacy implies that certain knowledge, skills and attitudes (ksa), drawn from the content of technology (however technology is defined), will be taught and learned. Presently, the technology education literature appears to contain three interpretations of the primary set of ksa's that comprise technological literacy.

One interpretation is that technological literacy means understanding the application of scientific principles (mainly those drawn from mathematics and physics) to the creation of tools and machines. When this interpretation comprises the primary component of technological literacy, then the content of technology education needs to be organized around the scientific principles that are to be reinforced; technology content is selected and structured to best illustrate and clarify the scientific principles. Pedretti's "Principles of Technology" illustrates this interpretation.

A second interpretation of technological literacy is to prepare students to work with technical systems; to have them learn skills, knowledge and attitudes about the systems that are uniquely technological (however broadly or narrowly technology is defined). This "technical" interpretation leads to drawing the content for technology education from the technological processes themselves, and to engage students in the processes.

The third interpretation of technological literacy is to understand and appreciate the impact of technology and its changes on individuals, on society and culture, and on the environment. One approach to achieving this type of literacy is historical, that is, to illustrate over time the impacts of technology and the effects of technological change. Another approach might be to have students plan, organize and conduct a production project, and then require them to introduce a "new" significant technological advance into the production process to illustrate the effects of such a change.

Thus, one can conceive of the content of technological literacy as varying within a 4 x 3 matrix. Four definitions of technology, each with a different scope, and three interpretations of the most critical kinds of knowledge, skills and attitudes to be learned from that content. Twelve definitions, plus innumerable combinations, can, therefore, be readily identified. But the problem of defining technological literacy does not end here.

What Level of Achievement Constitutes Literacy?

To define technological literacy for educational purposes, that is, to design instructional programs that will develop technological literacy, it is not only necessary to specify the kinds of knowledge, skills and attitudes that comprise the meaning of literacy, it is also necessary to identify the *level* of achievement that constitutes literacy. There is, after all, really a continuum of achievement in technology; individuals have varying degrees of competence. We may choose to bifurcate the continuum of achievement at some point to identify a minimum level of competence (what's above the line is literate and what's below the line is illiterate), but an artificial dichotomy is being created. Nevertheless, expectations of achievement do need to be expressed in designing formal education programs.

The literature of technology education already contains expressions which recognize a wide range of possible levels of achievement. As Dyrenfurth (1987) has already pointed out at this conference, the affective, cognitive and psychomotor behaviors that comprise literacy can be learned to different levels of complexity. Or, as Hameed (1987) and White (1987) have put it, literacy can be defined as having different functional levels, such as recognizing, using, controlling, making and designing, or put more simply, the consuming and the producing levels.

What is Technological Literacy?

Technological literacy at this time is, therefore, an ambiguous concept. Its meaning depends upon the interaction of one's choice of (a) a definition of technology, (b) the kinds of knowledge, skills and attitudes that comprise the primary substance of literacy, and (c) the level of competence it is necessary to possess to attain literacy.

By inference, technology education is an equally ambiguous concept. It too is in transition, in a state of "becoming." Progress as a field will depend upon reaching broader consensus about more precise definitions than presently exist.

Vocational Education

Vocational education, particularly at the secondary level, is also in a state of transition. Like industrial arts/technology education, the time available in the secondary curriculum for vocational education is being decreased because of increases in academic course requirements for graduation. But of even greater impact, the value of specialized occupational preparation at the secondary level is being seriously questioned by a growing number of influential critics. The criticisms are directed at issues of equity and of efficiency.

Criticisms of Vocational Education

In 1916, Dewey predicted that a narrow interpretation of vocational education as specialized programs for less-than-professional level occupations would harden the dichotomy of vocational and academic education. The former for the masses and the latter for the few economically able to enjoy it. Now, in 1985, Oakes reports that disproportionately greater numbers of students from the lower socioeconomic groups are taking vocational classes, and that the lower the skill level of the vocational course the more likely it is that the students will come from the lowest socio-economic groups. She joins Dewey in the charge that vocational education perpetuates a tracking system which intensifies an inequitable class system.

The charges of inefficiency have several bases. A number of studies, like Grasso & Shea (1979), have found that there is little (or no) economic benefit to secondary students who take vocational education courses. Employers often claim that the quality of graduates' performance is low, and that the time in vocational courses could be better spent improving basic academic skills (Research & Policy Committee of the Committee for Economic Development, 1985). Further, as Thurow (1986) believes, it is too costly to maintain equipment representative of modern industry in comprehensive high schools. Finally, there are those, such as the Panel on Secondary Education for the Changing Workplace (1984), who say that there is too great a discrepancy between the kinds of occupations demanded by the labor market and the kinds of vocational programs offered by schools.

Not all vocational educators find these charges credible, but a growing number do, and they are beginning to propose solutions that would significantly alter the curriculum of the secondary school.

A Proposed Solution

The solution most commonly proposed is to integrate vocational and academic education (Goodlad, 1984; Finn, 1986; Silberman, 1986). The proposal calls for defining the purpose of vocational education as improving "employability," broadly interpreted and career long. This means recognizing that vocational education is not only a form of specialized education, but that it must also seriously concern itself with aspects of the general education of *all* youth.

Proponents of this solution justify its reasonableness on both practical and theoretical grounds. They argue that the public continues to see the secondary school as a place to prepare for work (Gallup, 1985); work in the future will be more important than ever to a growing proportion of the population. It is claimed that much of the knowledge, skills and attitudes needed for success in any one occupation (or groups of occupations) is also needed for success in all occupations--in fact, the same competencies are also needed in many other life roles--and are thereby important for all youth to possess. Further, like industrial arts/technology education, vocational education is believed to provide an effective alternative approach to instruction; it provides a reason to learn, a way to learn, and a place to learn that can reduce drop-outs and improve the social and academic performance of students (National Commission on Secondary Vocational Education, 1986). And finally, while the need for specialized occupational preparation will not be eliminated, it will be delayed to the post-high school for an increasing number of students and become a life-long effort (Thurow, 1986).

Thus, it is likely that vocational education in the secondary school is also in transition. Most significantly, it appears that the direction of change is toward making the general education aspects of vocational instruction an increasingly important part of the high school program.

Bringing the Twain Together

Given the emergence of technology education with the purpose of developing technological literacy, and the possible transformation of vocational education to improve the employability of all youth (general education), the two fields appear to be heading on a converging course in the secondary school. What relationships between them should be envisioned? Are they on a collision course, or are they getting closer to working cooperatively?

A Reason for Cooperating

There is a very practical reason for cooperating--for seeking a common denominator that will permit the development of a conceptually coherent high school curriculum in corporating both fields. The reason is that by cooperating the chances of both fields finding a satisfactory place in the curriculum will be enhanced; by competing the chances of both fields will be substantially reduced.

Both fields are now competing with academic subjects for a place in the curriculum. Even the service areas *within* vocational education, agricultural education, business and office education, etc., often appear to be making independent arguments for their contributions to the secondary school curriculum. Separately, it is too easy for school boards and administrators to ignore the arguments, to place little credance in the claims, and to play one field (or service area) off against the other. Separately, we are viewed as claiming too much and producing too little. Together, by presenting one comprehensive plan, the probability of convincing other educators, as well as the public, increases dramatically.

A good example of cooperation is what happened in New York State (Good, 1986). The Board of Regents approved a plan that is not just technology education nor just vocational education. The Board approved a single, comprehensive plan for *all* occupational education and the practical arts. The plan allows for increased academic requirements, and it presents a systematic, sequential, *inclusive* approach to the development of core competencies common to all occupational areas, as well as those specific to more specialized areas (including technology education). It is quite likely that Board of Regents approval came as the result of the cooperative, unified planned undertaken by the practical arts and vocational educators in the State.

Technological Literacy: A Unifying Concept

Technological literacy may be the umbrella concept under which technology educators and vocational educators can jointly develop a conceptually coherent curriculum that includes both fields. It has that potential, provided the definition of technology employed is appropriate, and the interpretation of technological literacy is adequate.

A definition of technology recommended by both a historian of technology and the curator of a special library collection on the history of computers and technology at the University of Minnesota is one proposed by Gendron (1977). It reads:

> Any systematized practical knowledge, based on experimentation and/or scientific theory, which enhance the capacity of society to produce goods and services, and which is embodied in productive skills, organization, or machinery. (p. 23)

The definition serves the intended purpose well. It places science and technology in proper relationship; it limits technology to those systems which produce goods and services, but does not restrict them to industrial systems; and, importantly, it explicitly includes the practical knowledge embodied in the productive skills of individuals. The definition describes the source of content for vocational education as well as technology education!

Technological literacy could then mean the acquisition of knowledge, skills and attitudes about technology necessary for informed citizenship *and* for satisfactory productivity in and satisfaction with work roles. [Note that the concept of literacy is sufficiently encompassing to include both the consumer and the producer roles; the knowledge, skills and attitudes necessary for occupational performance is simply considered to be a high level of specialized technological literacy.]

The development of technological literacy could become a major purpose of schooling, viewed as a process requiring life long learning to satisfy both its consumer and producer applications. The major components of literacy include (a) understanding the systems of producing goods and services and their impact on individuals, society and the environment, (b) developing a vocational self-concept, and

(c) acquiring selected occupational competencies.

Thus, the development of technological literacy would span both general education and specialized education. It would be seen as an essential part of general (and liberal) education--the preparation needed by everyone for living in a society being transformed very rapidly by technology. It would be seen as an essential part of specialized education--the acquisition of specialized knowledge, skills and attitudes needed to make persons employable in highly technical productive systems. And it would be recognized and accepted that some of the specialized learning may occur for some individuals in the secondary school.

Conclusions

Vocational education can, indeed, play a role in developing technological literacy. More precisely, technological literacy can be the vehicle called for by the critics of vocational education to reconceptualize its purpose in the secondary school. But even more significantly, technological literacy can provide the umbrella concept under which technology education and vocational education can join hands and become part of the same developmental process--the process of achieving and maintaining technological literacy. As Thompson says, "Culture and vocation are inseparable and inseverable aspects of humanity" (1973, p. 226).

Obviously, this paper has concluded with only the germ of an idea. Whether it is an antidote to be cultivated or a virus to be exterminated, the reader will have to decide.

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